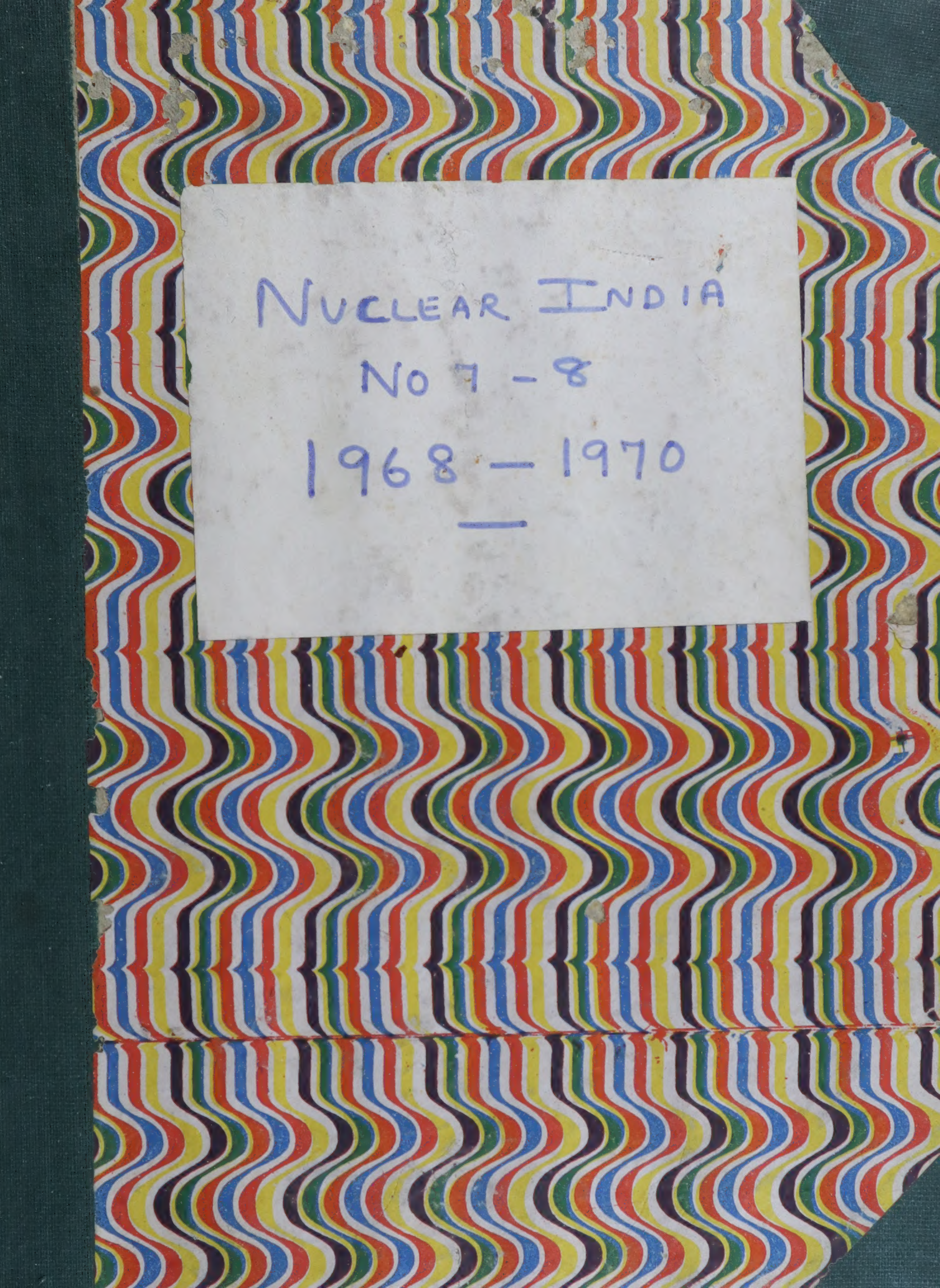

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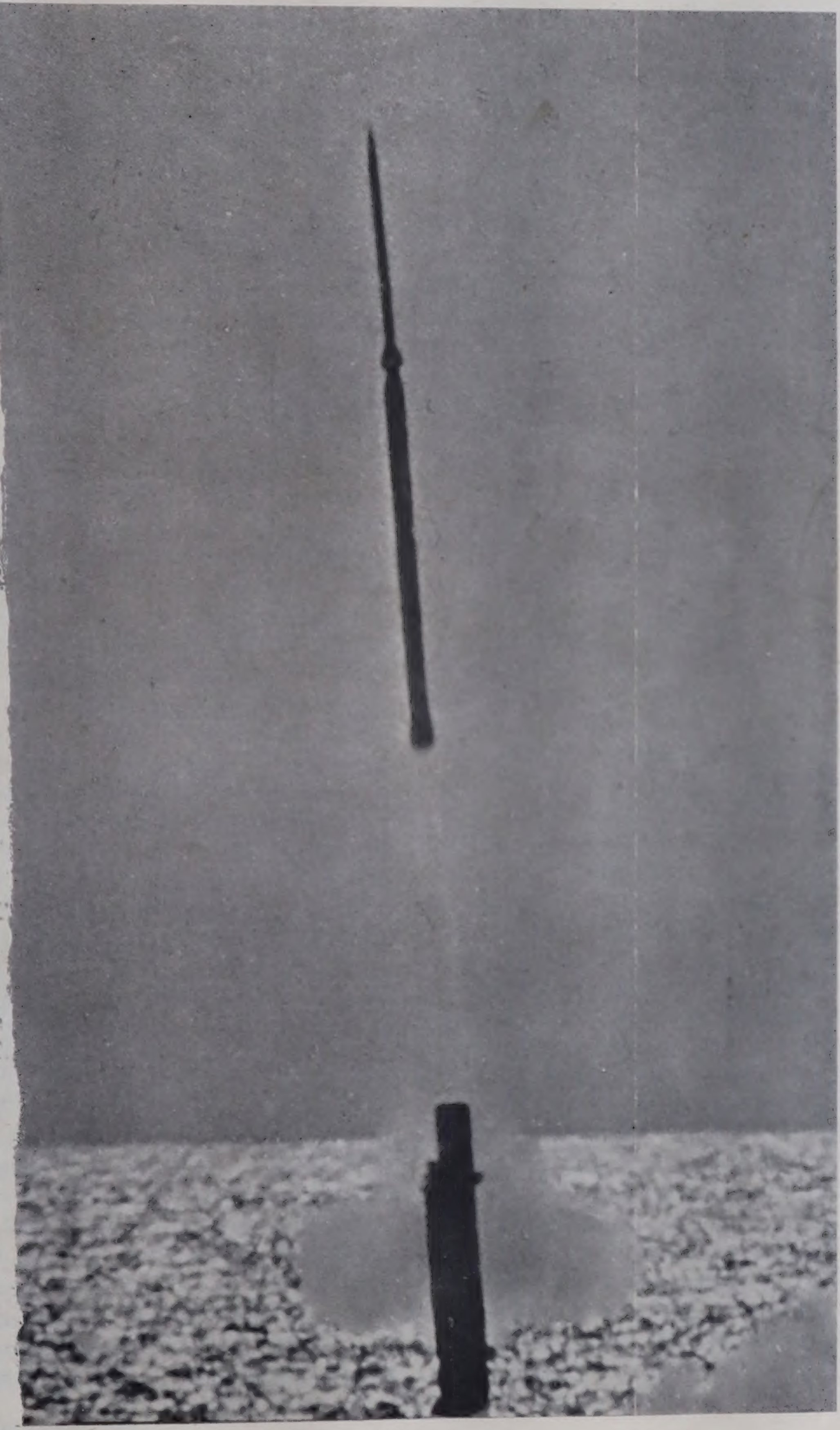

Thumba's Work On Menaka Rocket System

THE Menaka meteorological rocket system is being developed to evolve a suitable vehicle for studying atmospheric conditions in the region around 50 km altitude. Regular atmospheric soundings help meteorological scientists in the study of wind conditions and patterns in this region. Wind conditions are deduced from the drift and fall rate of S-band copper or aluminium chaff which is released from the rocket near the apogee and tracked by ground radar.

The Menaka effort is primarily aimed at developing indigenous rockets to replace imported ones. The design philosophy is to develop reliable and cheap rockets easy to transport and assemble and capable of being launched from remote sites by a crew of two or three. At present, flight tests of the prototype are continuing.

Two-Phase Development

The work on Menaka was taken up to utilize fully the existing know-how on propellants and materials in the country. The Explosives Research and Development Laboratory (ERDL) at Kirkee supplied a composite propellant while the Thumba Equatorial Rocket Launching Station developed the rocket and Dart payload systems. ERDL is producing the propellant grains to required specifications and has provided facilities for static testing of proof motors.

The development of the Menaka rocket is divided into two phases. In phase I, static and flight tests of the rocket motor are included to check design compatibility of various sub-

(Continued on page 4)

Left : *Menaka rocket take-off*

‘Space Already Bringing Qualitative

Text of the Speech by Dr. Vikram A. Sarabhai, Chairman, Atomic Energy Commission, at the United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, August 14.

THIS Conference, which marks the completion of a decade of the space age is appropriately held at the initiative of the U. N. Committee on the Peaceful Uses of Outer Space and through the directive of the General Assembly. The uses of outer space, peaceful as well as military, are already bringing about a qualitative change in our lives and can be expected to play an even more significant role in the future. The establishment of the U. N. Committee on the Peaceful Uses of Outer Space is indeed a recognition of this fact. Austria, our host country, has provided Chairmen for this important Committee, who have guided its affairs with leadership, understanding and tact. The holding of this Conference in Vienna today is largely the result of the untiring efforts and initiative of its Chairman, who we are fortunate to have today as our President.

I deem it a great privilege to have been nominated Vice-President and Scientific Chairman of this Conference. I trust that through my work I will be able to convey my appreciation of the honour you have done me.

India has established at Thumba, with the active cooperation of the United States, the Soviet Union and France, an equatorial sounding rocket range. This international facility has received U. N. sponsorship and is a unique example of nations following different political paths joining resources for promoting the peaceful uses of outer space. Modest as that experiment is, I believe it provides a model of great significance to the future. So too is the Experimental Satellite Communications Earth Station at Ahmedabad which has received support from the United Nations Development Fund and the International Telecommunications Union, and now runs an international training centre. United Nations' assistance to the project, pledged several years ago was a forward looking departure from established practice in such matters. For, it involves a recognition of the proposition that advanced projects, even ones dealing with outer space, can be of relevance to the real problems of a developing nation. The trust displayed by the concerned international agencies in accepting our interest as a serious one, has I believe been fully borne out by subsequent events. India is now putting up a commercial earth terminal for satellite communications with system's responsibility and project execution undertaken by its own nationals who have acquired competence and self-confidence through participation in the earlier project. A 98-foot fully steerable antenna is also being fabricated in India. Moreover, equal benefits from the project flow to the nationals of the many countries, forming more than half of the trainees in the courses given at Ahmedabad.

I believe that several uses of outer space can be of immense benefit to developing nations wishing to advance economically and socially. Indeed without them, it is difficult to see how they can hold their own in a shrinking world. I shall try to outline today some of the objectives of space research and some implications of the practical uses of outer space. Drawing on experience gained through professional involvement and management responsibility for atomic energy and space research and their applications to tasks of national development in India, I will share with you some of my thinking on the problems encountered in realising practical benefits from advanced technologies. Finally, I will examine the type of international collaboration that I believe is required before large number of nations in the world, developing countries as well as small advanced countries, can partake in the benefits of outer space.

The sun provides the driving force for almost everything that happens on earth; weather, rivers, vegetation, fossil fuels and of course life itself. But in contrast to the apparent constancy of the sun and the complete dependability of sunrise and sunset, we experience a capriciously variable environment, the fury of hurricanes and lashing ocean waves, droughts and floods, starvation one year and bumper crops another, and uncertain radio communications. The natural scientist looking for the subtle links through which the sun affects the earth and our lives has at last acquired, in the exploration of space, a dramatic new capability for study. He has discovered that in the solar system, the space separating the sun and the planets is filled with extremely rarified matter constantly flowing outwards from the sun with a velocity of about 300 to 500 kilometers per second. The solar wind as it is called, carries with it the sun's magnetic field, and the regime around planets is, broadly analogous to what happens when a big boulder sticks out in the middle of a swiftly flowing stream of water. The sun itself is not placid, and the surface is not uniform. Apart from beauty spots showing up every now and then, it throbs like a boiling cauldron and it experiences storms of great violence.

There is another major interest in exploring space. The earth's crust and the lower atmosphere have temperatures and densities such that electro-magnetic and hydrodynamic phenomena function largely independently of each other. But this state is rather special and does not commonly occur in the universe. Even on earth it does not occur in the molten core or if we go upwards beyond 80 or 100 kilometers. In the sun and the stars as well as in inter-stellar and inter-planetary space, electromagnetic and hydrodynamic behaviour are intimately linked. In consequence fluids be-

Change in Our Lives'

ave in a manner unfamiliar to us nd there are many open questions or which laboratory experiments are of limited use since they do not simu-ate what happens on a cosmic scale. Space research has at last made direct experimentation possible in the magnetosphere of the earth and in interplanetary space.

A third important scientific objective has been to view the universe, the galaxy and the solar system through a wide window. The blanket of the atmosphere under which we live eliminates all but a tiny fraction of the broad spectrum of electro-magnetic radiations and particles which impinge on the earth carrying with them information about the sources where they originated and the properties of the media through which they have traversed. Depending merely on observations made with earth-bound instruments to picture the universe and understand cosmology is like the attempt of a blind-folded man to describe an elephant by touching the trunk and the legs of the animal. Through space research we have now become aware of X-rays not only from the sun but from strange distant objects in the galaxy . The intensity often changes in a most interesting manner within a short period of a few days. Planetary research is helping us understand the origin of the solar system and the crucial question of the existence of extra-terrestrial life. We shall hear more about these exciting discoveries during the Conference. But I wish here to pay a tribute to the scientists and engineers who have pioneered in this field. Particular mention is appropriately made of the outstanding contributions of the Soviet Union and the United States.

Technological advances which have provided weightlessness and permitted man to free himself from the solid earth have opened a vast field of human knowledge where, as yet, we are only scratching on the surface. They have also produced major qualitative changes of social and political significance. I suggest that the practical benefits are not realised in full measure unless the applications are undertaken side by side with the serious pursuit of activities which go beyond installing black boxes. They need the investment and commitment of nationals of the country in related fundamental and applied sciences and innovative tasks. Moreover, in realising these benefits, the most difficult problems are neither technological nor economic, but related to human and social factors.

We should note that the peaceful uses of outer space, as for example in the field of telecommunications or meteorology, involve developments along advancing frontiers of science and technology. They produce rapid obsolescence not only of hardware, but established systems of organisation, of administrators and technicians responsible for providing national services. The full benefits of outer space can be realised only when nationally and internationally an appropriate culture can be created. I recall our own experience in establishing a modest programme for studying equatorial aeronomy with sounding rockets from Thumba. It became quite obvious that we could succeed in executing such a programme only when the necessary social change occurred to permit an inter-disciplinary group of specialists and innovators to work competently for a well-defined common objective.

We shall lose perspective in interpreting the social implications of space science and technology if we fail to recognise that those developments form an important part, of a wider set of diverging human functions. A characteristic property of such functions is best illustrated by understanding the meaning of a number expressed as a power, for instance, three raised to the power of eighteen, which is about 390 million. In dynamic terms it illustrates a very interesting feature of divergent functions. If a man were to spread a gossip to three other persons and each of these three would convey it to three others and so on, it would take just 18 steps for all the people in a nation as large as India to know the spicy story. Note that if each step takes one hour, ninety per cent of the people get to learn the story only during the last two hours, the 17th and the 18th hour. Indeed during eighty per cent of the time the process affects only 10 per cent of the population. All things which involve the human element, for example, population, knowledge and innovation, have this characteristic property. Like biological infection which propagates almost unnoticed through many steps but makes its onslaught felt all of a sudden, so too, the social impact of innovative man has hit society like an avalanche. Scientific advances and technological innovations along with their social and political implications have suddenly overtaken the pace of the human life cycle and produced a crisis of obsolescence.

Many political implications arise from the military uses of outer space and surveillance by satellites. National security and sovereignty have been eroded while privacy has been encroached upon. When security is threatened not by a hostile neighbour but by the actions of distant powers, what is the relevance of traditional concepts in international relations such as spheres of influence and power politics, of bases and alliances ? Obsolescence of thinking and patterns of behaviour in international affairs poses today a most serious threat to our survival.

The greatest cost-effectiveness of the uses of outer space occur through large scale applications rather than those of limited scope. A communication satellite can most effectively serve communities dispersed over large areas. Meteorological applications of satellites are likewise most relevant for a global system like the World Weather Watch. This creates two types of problems, both of which

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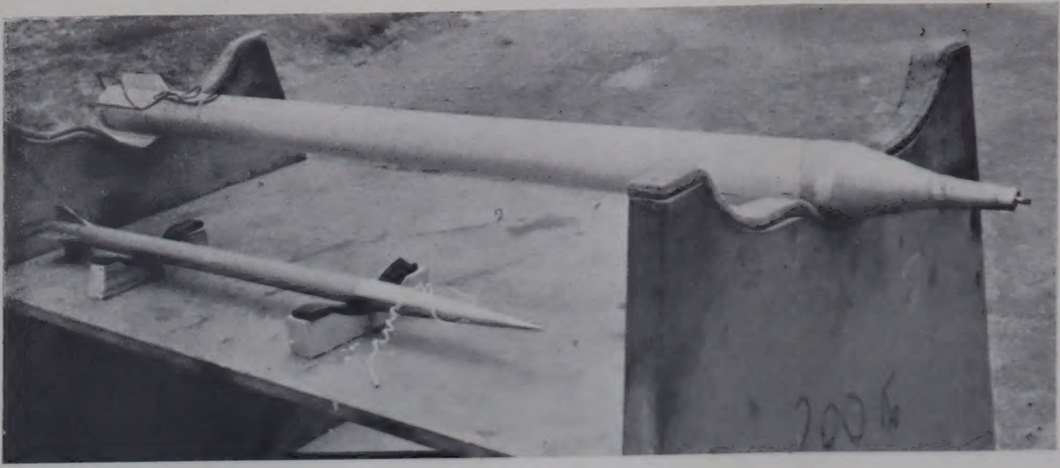
Menaka . . .



systems of the rocket, and to optimize the design, assembly and launching techniques. In phase II, motors would be based on an optimised design with a higher thrust-to-weight ratio to achieve 50 km altitude with 4.5 kg payload.

The system consists of a D-1 booster and Dart payload (see figures), which is assembled to the head-end of the booster prior to launching. Some of its important characteristics are given below. The assembled rocket is placed in the tubular launcher fitted with spiral guide-rails which impart approximately 10 rps spin rate to the rocket on take-off for improving stability during flight. Ignition is accomplished by providing a surge-current from a D.C. source. The booster drag separates from the Dart after burnout (1.6 sec) and the Dart traverses a ballistic path. A delay-column incorporated in the Dart and initiated at take-off, ignites an explosive charge placed in the head-end of the Dart, which in turn drives a piston through the length of the Dart tube. The Dart fin assembly shears off and the S-band chaff bundles are ejected. The dispersed chaff forms a radio-reflecting cloud moving with the prevailing winds and descending at a slow rate. Radar tracking data of the chaff cloud provides information on the wind (speed and direction) at different altitudes from the point of release to ground level.

The assembly procedure and launching techniques involve a minimum of operations and a team of three is sufficient to accomplish the launching.

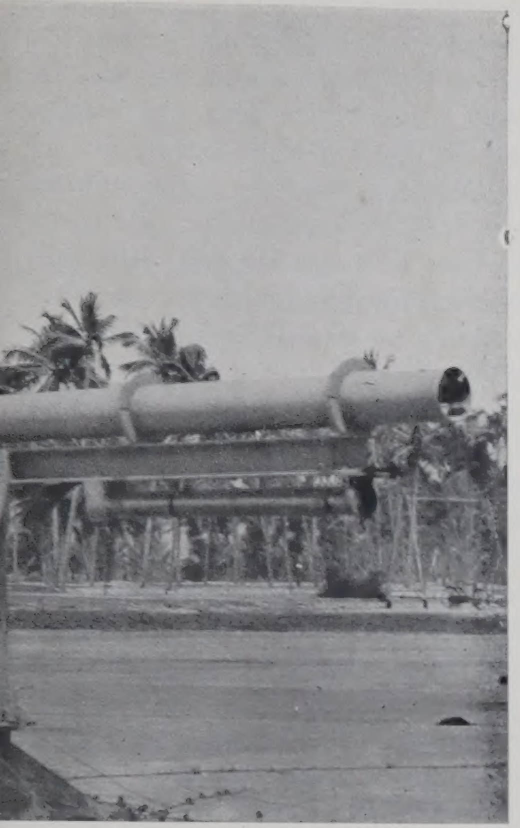
Flight tests of Menaka MK-I are in progress while further development of MK-II has been taken up to achieve optimised performance.

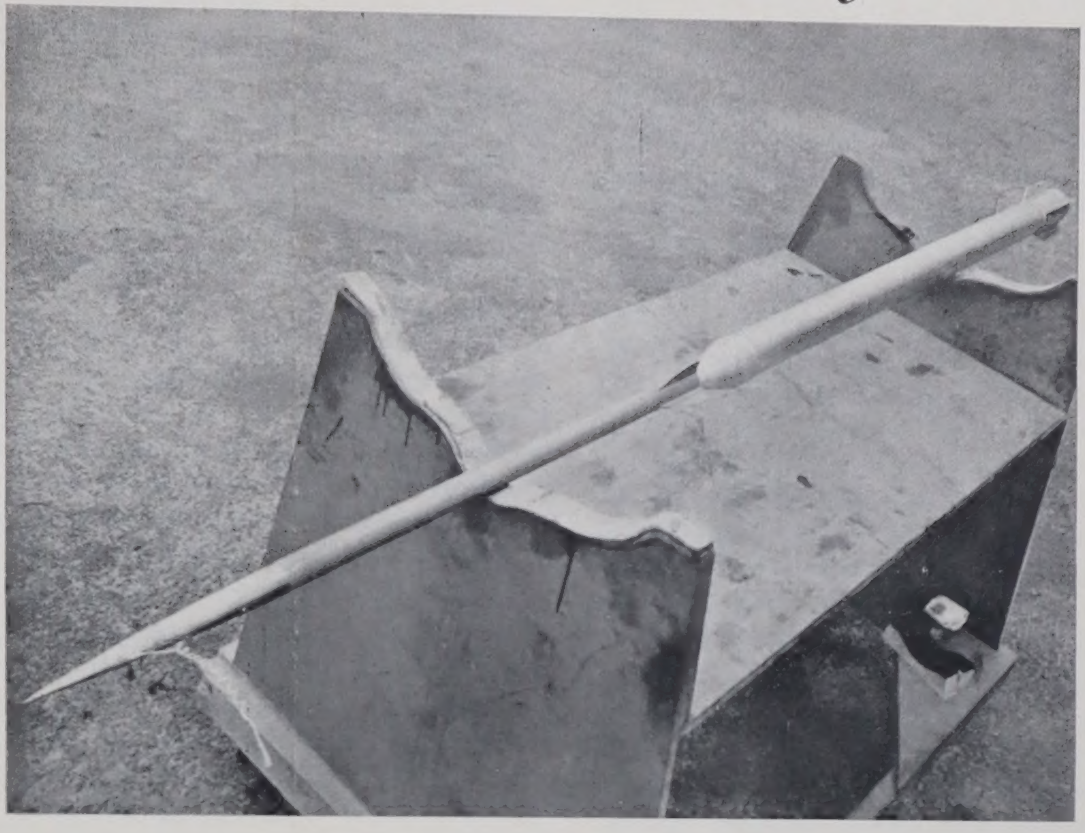
THE MENAKA SYSTEM

Dimensions	
Length of D-1 booster	– 1534 mm
Diameter of D-1 booster	– 74.8 mm
Fins	– Cruciform
Length of Dart	– 1022 mm
Diameter of Dart	– 35 mm
Fins	– Cruciform
Over-all length of Menaka system	– 2483 mm
Propellant Characteristics	
Type	– Composite
Specific impulse	– 217 secs at 0.910 kg/mm^2 pressure
Burning time	– 1.6 seconds
Weights	
Weight of D-1 motor	– 8.64 kg
Weight of Dart (with .36 kg chaff)	– 4.00 kg
Take-off weight of Menaka	12.64 kg

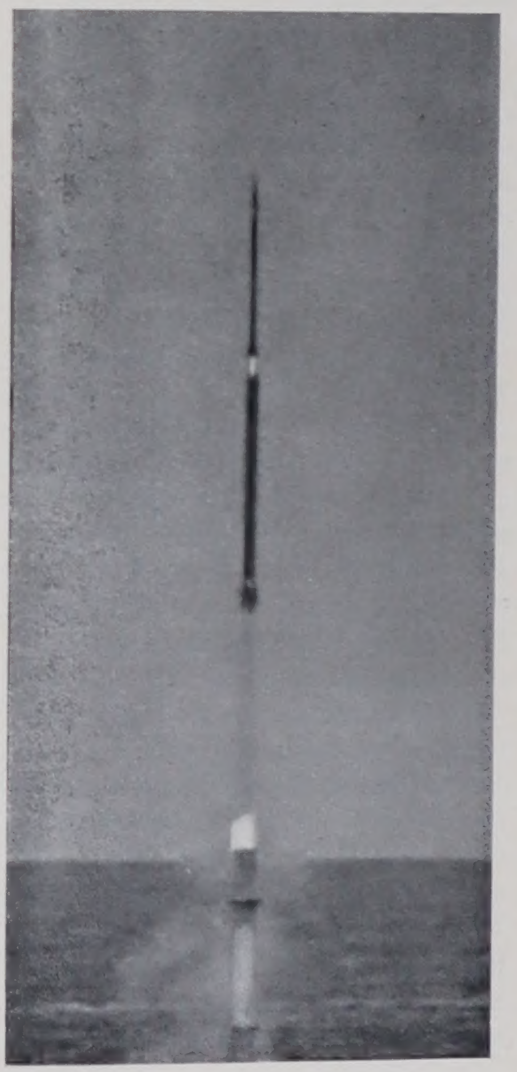
Assembly, loading and launching of the Menaka s

A Meteorological Rocket System





eft are Menaka and Dart before assembly. The photographs below show the loading and first launching of the Menaka rocket, March 24, 1968



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'Knowledge Cannot Be Contained'

are particularly acute to developing nations and to small advanced nations. In the first place there is the difficulty of providing on an exclusively national basis either the effective utilisation or the resources for deploying the new system. Generally in developing countries, the telecommunications traffic is not large enough to permit effective utilization of a satellite; the national meteorological organisation is not equipped to make use of world-wide data for improved forecasting or to contemplate projects for weather modification. Under these circumstances, the benefits of the uses of outer space truly accrue only through international cooperation based on interdependence Indeed, the situation here brings out dramatically a feature which is not peculiar to outer space but to many other fields of technological development; of monolithic technological systems created to serve social groups with diverse cultures, history and political objectives.

S pace research shares with the growth of electronics and of atomic energy—the characteristic that its progress has depended very crucially on the interplay of fundamental sciences with technology. Just as solid state physics has contributed to electronics and nuclear physics to reactor technology, several fundamental sciences have contributed to space research. This has the important consequence of providing to the practical applications an inbuilt culture of international science—propagating beyond national frontiers, permitting two way communications not constricted by commercial considerations nor even subject to effective containment on national considerations.

This Conference is to lay special emphasis on the benefits which can be derived by developing countries from participation in the peaceful uses of outer space. The primary concern of such nations must presumably be social and economic development, and indeed during the last 20 years, we have seen an increasing realisation, at least intellectually, of the grave threat that exists to the security of the world through wide disparities in the standards of living in different regions. But a relevant question to ask in this context is, why in spite of much that has been attempted bilaterally, regionally and through international agencies, the gap between the advanced and the developing nations has widened rather than decreased? In examining the question from a different angle, I have asked myself the question why is India one of the most expensive poor countries? I could observe two important factors. First that since developing nations by definition start from a low economic base, their incremental growth, large as it might be when expressed per cent wise, is intrinsically small compared to the incremental annual growth even of much smaller economically advanced nations. Thus, a developing nation following a step by step approach towards progress is landed with units of small size, which do not permit the economic deployment of new technologies. Through undertaking ventures of uneconomic size with obsolete technologies, the race with advanced nations is lost before it is started. Indeed, if one continues to operate on this philosophy, financial and technical assistance from the advanced nations to the developing nations can only result in the frustration of the former and the increasing economic dependence of the latter.

A positive approach out of this predicament seems to lie in finding solutions where the particular disadvantage of developing nations, which is that they have little to build on, is made an asset rather than a liability. I suggest that it is necessary for them to develop competence in advanced technologies and to deploy them for the solution of their own particular problems, not for prestige, but based on sound technical and economic evaluation involving commitment of real resources. They would most likely discover that the traditional approach of planning to provide things like electric power or telecommunication services for a national infrastructure, based on projections of growth from past experience leads to a dead end. They will also discover that an alternative approach lies in creating consumption centres alongside facilities for supply; that as in the case of large nuclear power stations serving agro-industrial complexes, synchronous satellites could be planned in the context of a programme to be simultaneously undertaken for direct broadcast television to the entire countryside. Indeed they would discover that there is a totality about the process of development which involves not only advanced technology and hardware but imaginative planning of supply and consumption centres, of social organisation and management, to leapfrog from a state of backwardness and poverty.

D eveloping nations which have a large area and big population, such as India, have the possibility of effectively utilizing space communications systems for national needs. Compared to advanced nations such as the U.S.A., Canada and the U.S.S.R., they have indeed an advantage through not having an existing major investment in older technologies. For them the principal problem is of mobilizing resources and of developing them adequately. The most important input I regard in this exercise is of course the human element of trained engineers, scientists and managers, of people who understand not only the technological but the social implications of the system which they wish to deploy. Developing nations differ widely in regard to existing human resources of the requisite type needed to partake in the peaceful uses of outer space. In India, for instance, when independence was achieved, there were in the country tens of thousands of engineers and scientists and several thousands abroad. The capability of such a country where scientific investigations dealing with meteorology, geomagnetism and astronomy have been conducted for more

Artificial Boundaries

than 100 years and a sophisticated culture and tradition for learning exist, is quite different from that of developing countries with a much weaker professional base. True, that expressed as a per cent of population the number of professional scientists and engineers in countries, such as India are small; but in absolute terms they compare well with the numbers that are found in nations such as Germany, Italy or Japan. Moreover since advanced technologies require skilled personnel in large measure the situation is not different for advanced and developing countries. Under these circumstances, surely, the developing countries with a professional base have an economic edge in a straight competitive situation.

At the moment, in India we are deeply interested and involved in an evaluation of the benefits that a synchronous satellite can provide for national needs of point-to-point communications, for mass communications through direct broadcast television to promote national integration as well as the economic development of isolated communities, for meteorological observations covering the vast Indian ocean and for assisting navigation. Just for one application, namely, the provision of broad-band communications for reaching through television half a million villages of India, it can be shown that using satellites the investment would be only about a third of what would be required with conventional technologies. Where capital funds and foreign exchange are crucial bottlenecks, the deployment of a satellite communication system based on a largely indigenous effort in electronics can make all the difference to a national decision for adopting the most effective and pursuasive means as yet available for mass communications. Indeed it is estimated that with an annual investment equivalent to about 40 million dollars, one can provide community television to all the 560,000 villages in India over a five-year period. This would incidentally generate a strong industrial base in electronics providing employment to about 120,000 qualified scientists, engineers, technicians, managers and other administrative personnel. But before such programmes can be undertaken, there are formidable problems, which perhaps many developing countries would encounter.

First, we often meet with lack of self-confidence to pursue major tasks involving complex and unfamiliar technologies. There is also an in-built culture within which a major departure from existing well proven systems, and anything which is innovative in character is automatically regarded with suspicion. The administrative structure of Governments in many nations is dominated at the top not by technocrats but by professional administrators, lawyers or soldiers, who are hardly likely to provide the insights, experience and the first hand knowledge of science and technology which are necessary at the decision making level. Moreover, advanced nations often play a negative role in their interaction with the developing countries. There is seduction by their political and commercial salesmen who dangle new gimmicks which they suggest should be imported rather than indigenous capability be developed and supported. There are those who preach as guardians of the economic well-being of the developing nations that they must proceed step-by-step following the same process by which the nations themselves progressed. One is often told that such and such a thing is too sophisticated to be applied. This approach disregards what should perhaps be obvious, that when a problem is great, one requires the most effective means available to deal with it.

One of the hardest questions to be faced in adopting a synchronous satellite for national needs, arises from the fact that many interested countries would not expect in the near future to have an independent capabiity for placing such a satellite in orbit. The nations advanced in space research of the peaceful uses of outer space to all countries, and one can reasonably count on their continued support. But the political implications of a national system dependent on foreign agencies for launching a satellite are complex. They are not negative in the present day world only in the context of the coming together of the national interests of the launcher and the user nations. As long as there is no effective mutuality or interdependence between the two, many nations left only with the ground segment would probably feel the need for some measure of redundant capability under complete national jurisdiction. There is great scope today to explore this structure of possible international systems which could provide credibility in increasing measure that the space segment could be relied upon even in the context of political and ideological differences amongst nations.

Perhaps collaborative participation of nations in the construction and operation of a launching system for the peaceful uses of outer space would be realised in the long run. The military overtones of a launcher development programme of course complicate the free transmittal of know-how of technology involved in these applications. But it is important to note a fundamental aspect of human development that knowledge cannot for long be contained within artificial boundaries and one has to learn to share and to control rather than control harmful effects through withholding transfer of technology or knowledge. After all, the biggest secret regarding the atom bomb was let out when, through the demonstration of the explosion over Hiroshima, it became known to everybody that the device worked. Similarly, the biggest secret in space research became public property when the successful orbiting of the first Soviet satellite proved that this feat was possible. Thereafter, it is merely a question of time. Restrictions on the transfer of technologies which are involved in the

(Continued on page 8)

Colloquium on Cosmic Ray Studies at TIFR

A colloquium on "Cosmic Ray Studies in Relation to Recent Developments in Astronomy and Astrophysics" will be held at the Tata Institute of Fundamental Research, Bombay, from Monday, November 11 to Saturday, November 16, 1968, both days inclusive.

About 20 scientists, including about 10 from abroad who are engaged in research on Cosmic Rays, Astronomy, Astrophysics and Cosmology will lecture in this colloquium. Speakers from abroad will include Professors A. G. W. Cameron, W. A. Fowler, E. N. Parker and B. Rossi, (all from U.S.A.), Prof. W. H. McCrea from the United Kingdom, Prof. S. Hayakawa from Japan and Prof. B. Peters from Denmark. One or two scientists from the U.S.S.R. and one from the Mullard Radio Astronomy Observatory, Cambridge, U.K., are also expected.

Space Conference

(Continued from page 7)

peaceful uses of outer space merely jeopardise the security of the world through retarding the progress of nations.

A physicist is trained to accept that what is not possible in theory, is not realisable in practice. This elementary experience can well be applied in planning international systems for promoting the peaceful uses of outer space; as indeed also for peaceful nuclear explosions. Those systems that do not provide full participation by all nations in all aspects of technology in which they are competent to partake in, are, in my humble opinion not saleable, much less sustainable in the long run. Attempts to promote them merely poison international relations and the climate of cooperation. I hope that at this Conference fresh thinking on this subject will be generated.

A mini-power-station for space travel is currently being developed by German scientists. This new source of energy for large satellites, space stations, space craft and moon bases is fed by a reactor core which is only 35 centimetres in diameter and 45 centimetres high, producing 20 kilowatts. It produces energy without moving parts and is largely resistant to shock. (Photo : courtesy IN-Bild/WF-Siemens.)

Unlike atomic energy for which there is a specialised agency of the United Nations with its headquarters in this city, there is for outer space in New York a separate division at the U. N. and there is also the U. N. Committee on the Peaceful Uses of Outer Space. The resources at the disposal of the outer space division are totally insufficient for it to perform an active role. I would earnestly urge that serious consideration be given to redefine its responsibilities and role providing appropriate back-up to stimulate on a continuing basis the understanding and the utilisation by all nations, of the uses of outer space. There is much scope for opening the doors to permit access to all of the advances in space technology. If this Conference is to the peaceful uses of outer space, what the first Atoms for Peace Conference was to atomic energy, the high expectations with which we are assembled here today would be fully realised.

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Need to Safeguard IAEA's Primary Role of Promoting Peaceful Uses of Atomic Energy

Address by Dr. Vikram A. Sarabhai, Chairman, Indian Atomic Energy Commission, at the 12th General Conference of the IAEA in Vienna on September 26.

THIS year we have circulated beforehand the account of atomic energy developments in India and this makes my task easier at this session. I would like however to highlight a phase which is of some significance to all countries, and particularly to developing nations. Having spent 15 to 20 years in establishing the ground base for atomic energy, India is now exploring in some detail, the applications of atomic energy in various fields of national development, and apart from power and agriculture about which I shall discuss in much greater detail in my lecture this afternoon. I wish to draw pointed attention to the very great scope which seems to exist in the irradiation of potatoes and onions, crops which are of great importance in the tropics.

Our own evaluation shows that in this field there are very large returns to be had and I am sure that with the facility which we have put up in India in collaboration with Canada, which we call the Fiply facility, much scope exists not only for making trials in our own country but also for making this

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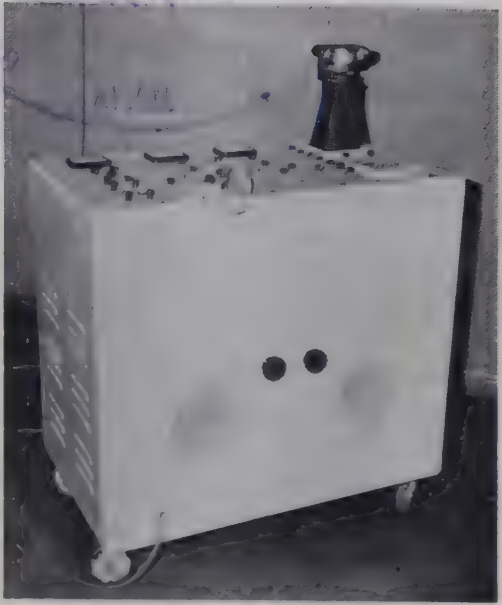
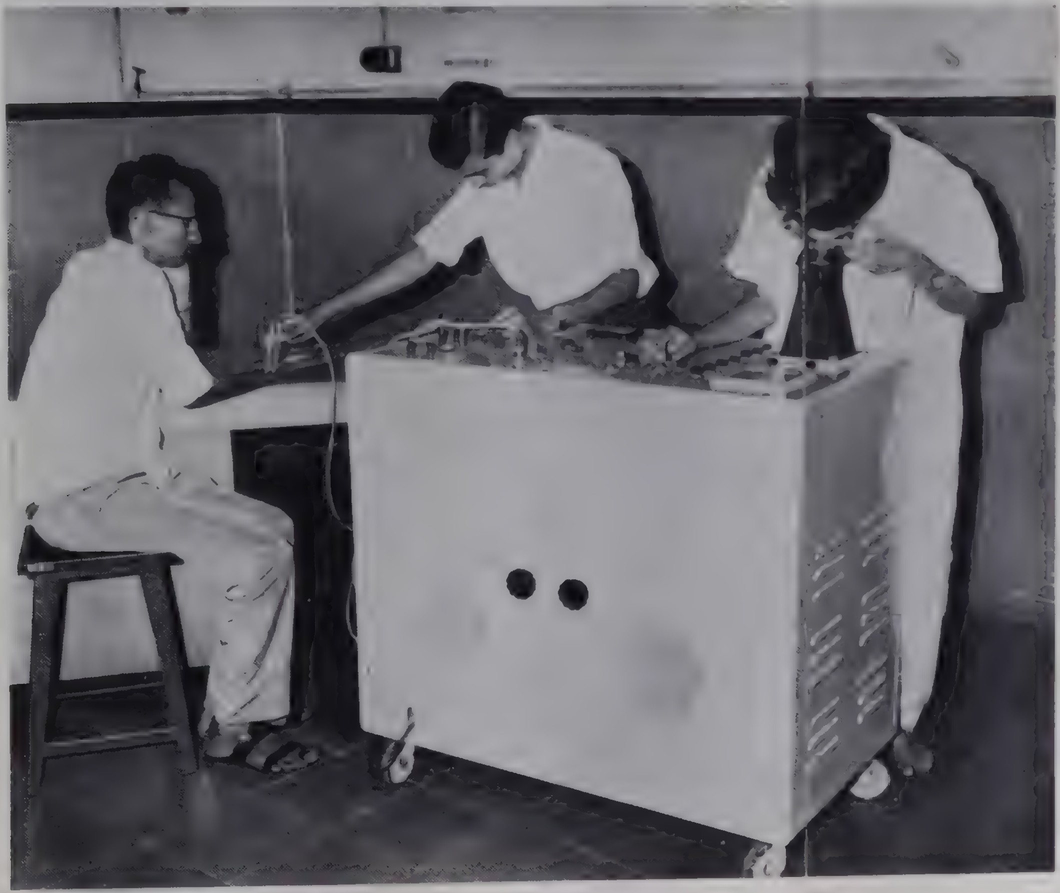


2-channel electromyograph developed at BARC. At left, the equipment is shown undergoing clinical tests at the Post Graduate Laboratory of the J. J. Hospital, Bombay.



An Electromyograph Developed at BARC

THE Electronics Division of the Bhabha Atomic Research Centre, Trombay, has developed an important diagnostic and research tool for the medical profession. Commonly known as the Electromyograph. (EMG), this piece of equipment helps in the investigation of neuromuscular paralysing disorders such as leprosy, poliomyletis, muscular dystrophy and similar maladies which are prevalent in India. This system is likely to assume the same importance in the investigation of neuromuscular disorders as that which the electro-cardiograph has gained in the diagnosis of cardiac disorders or the electro-encephalograph in the investigation of cerebral disorders.

The advent of electromyography as a branch of science has called for inter-disciplinary coordination be-

(Continued on page 8)

Mystery X-ray Stars

X-ray astronomy today is at the stage which radio astronomy had reached a year or two after the end of the last war. Many astronomers believe that we shall eventually learn as much about the universe from the mysterious sources called X-ray stars as we have learnt from radio stars. Unlike radio waves, X-rays do not penetrate the atmosphere and so must be studied from above it.

by John Newell

MOST British observations have been made from X-ray detectors mounted in the nose cones of Skylark rockets. Last April, one in a series of launchings from the Australian range at Woomera, located a new powerful X-ray source in the heavens. As only some 30 X-ray sources have been found so far, the new one was the subject of special interest, but by the time a third rocket was launched to look at it, only a matter of three weeks later, it had become much weaker. By September it was only just detectable, and now it has disappeared completely. Astronomers calculate that this X-ray star could only have been giving X-rays at all for about two years. This is an astonishingly short length of time for any important stellar process. Big changes in stars normally take thousands of years. This one may cast a completely new light on the evolution of stars.

One theory of the nature of X-ray stars is that they may be double stars, partners who swing round each other, only a million miles or so apart. From time to time, so the theory goes, the partners stray too close together and the gravitational pull of one strips the outer layers off the other, exposing its super heated heart. Very high temperatures are required to produce intense streams of X-rays; the exposed part of the star would provide them. Another recent theory is that X-ray sources are novae or exploding stars. One X-ray source which has been located, in the constellation Centaurus, may be a supernova, a much less common and more violent type of explosion. Another possibility is that the X-ray sources represent collapsing stars which have shrunk. In shrinking they would be heated up to several million degrees Centigrade, enough to produce torrents of X-rays. These collapsing stars are very hard to observe and if they exist, which is still not certain, then they are one of the most important phenomena in the universe. This is one reason why astronomers are so anxious to observe them. Another is that X-ray sources have all been found so far in those parts of the universe with a preponderance of very young visible stars and of the clouds of hydrogen gas from which it is believed stars are born. So there

(Continued on page 8)

A Skylark rocket launched from Woomera, S. Australia,

Cyclotrons for Nuclear Research

by A. S. Divatia,
Nuclear Physics Division,
Bhabha Atomic Research Centre, Trombay

THE main objective of nuclear research is to seek an understanding of the forces that bind together the sub-nuclear particles, such as the protons and the neutrons inside a nucleus. These forces are complex and defy simple representation. Nuclear research, therefore, demands a multifaceted and intensive study, requiring a variety of sophisticated tools.

An accelerator is a powerful tool for nuclear research. Its function is to accelerate to high velocities charged nuclear particles, such as protons, deuterons, alphas and also heavy ions. An accelerator may be linear or cyclic. The Van de Graaff accelerator is a linear electrostatic accelerator, whereas the cyclotron is a cyclic electromagnetic accelerator. The cyclotron is the first cyclic accelerator, and it has played a unique role in the development of basic ideas in nuclear physics.

Principle of operation of the cyclotron

The operation of a cyclotron is illustrated in figures 1 and 2. Positive ions, produced and accelerated in a chamber placed in the field of an electromagnet, move in an orbit spiralling outwards. The radius of the orbit increases as the energy of the ions increases. The acceleration of the ions is done by applying an alternating radio-frequency voltage on the dee electrode. If there are two dee electrodes, the voltage is applied between them. The radio-frequency is synchronised with the motion of the ions in such a way that the voltage accelerates the ions while entering the dee as well as while coming out of the dee. If there are two dees, the acceleration takes place when the ions cross the gap. The maximum energy of the ions is reached at the outermost orbit. This principle of operation can be illustrated by an analogy, as shown in figure 3 (p. 4). Two cricketers, standing on opposite sides of a pole give hits to a ball tied to the top of the pole with a string. The hits are synchronized so that the ball, acquiring higher and higher velocity moves outwards in a larger and larger radius. In the cyclotron, an ion being accelerated behaves like the cricket ball, the difference being that the motion of the ion is confined to one plane, unlike the ball. The energetic ions so produced can bombard a target and produce a nuclear reaction, resulting in a nuclear transmutation.

The cyclotron was conceived by Ernest O. Lawrence at the Lawrence Radiation Laboratory of the University of California, Berkeley, U.S.A., in 1929. By the end of 1930 he had built the first cyclotron, producing hydrogen ions with energies of 80,000 electron volts. The development of this machine led to the study of nuclear reactions produced by accelerated ions, resulting in great leaps forward in the field of nuclear physics. Lawrence received the Nobel Prize for this outstanding contribution.

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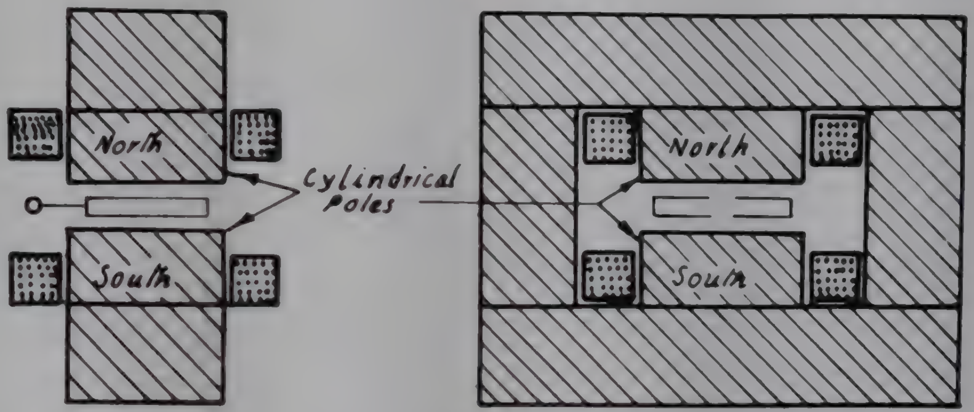
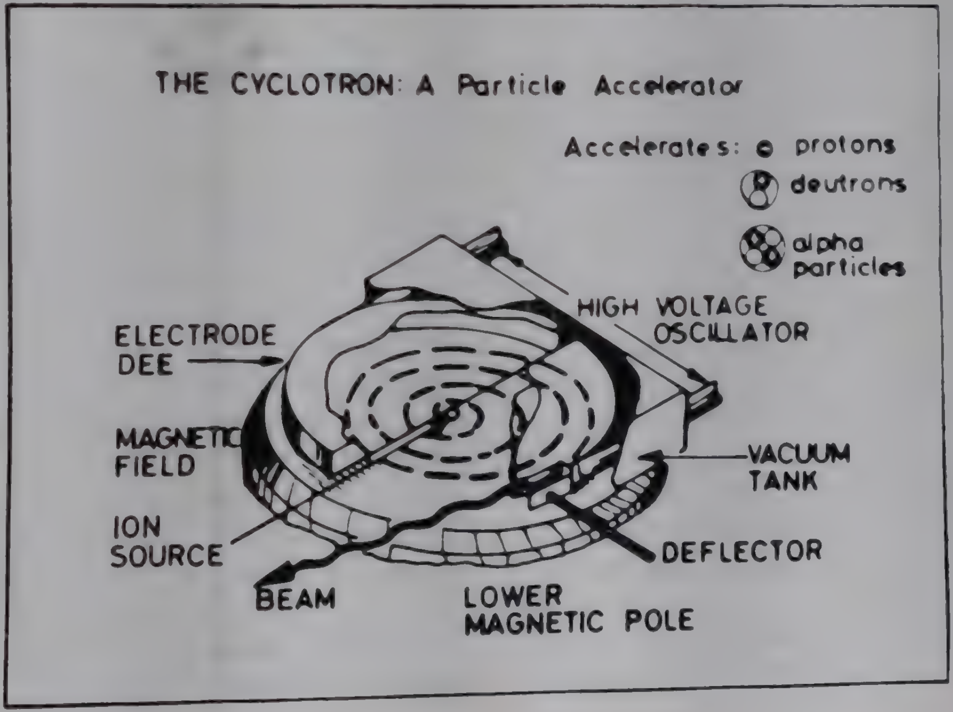


Fig. 1. Two cross sections of a cyclotron showing the electromagnet consisting of the magnet frame and the current coils. Two dees are situated in the magnet gap between the two cylindrical poles.
Fig. 2. A cutaway view of the dee chamber or the vacuum tank of a cyclotron, showing a single dee electrode, ion source and the deflector, and the spiralling ion orbit. The high voltage oscillator feeds the radio-frequency power to the dee electrode.



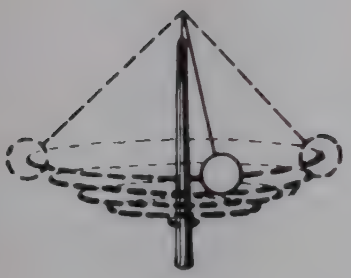


Fig. 3 Mechanical analogy of cyclotron acceleration. The ion acceleration is similar to that of a cricket ball being hit synchronously by two cricketers to produce a spiralling motion of the ball as it is accelerated. Unlike the ball, the ion motion is confined to a plane.

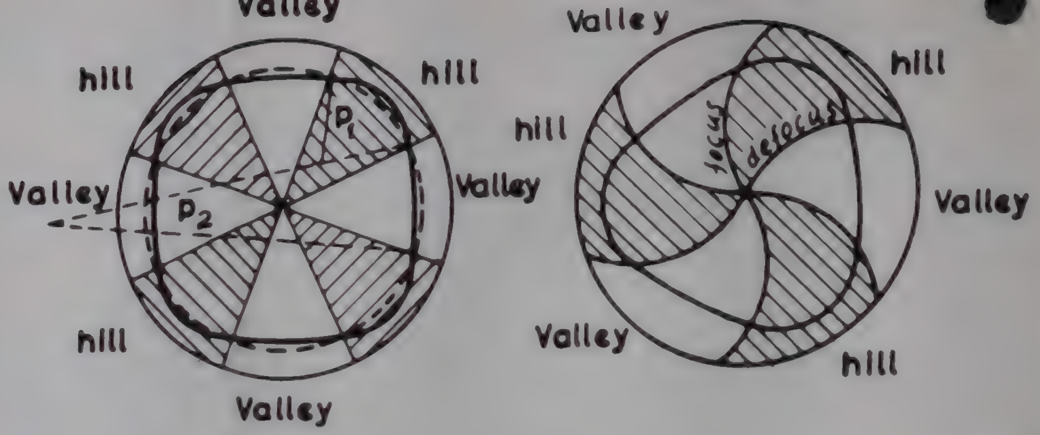


Fig. 4 Two possible configurations of the pole pieces of an azimuthally varying field (AVF) Cyclotron. A hill region corresponds to a region of narrow gap and higher magnetic field, whereas a valley region corresponds to a region of wide gap and lower magnetic field. Focussing and defocussing takes place at the transition regions, the net action being focussing. The ion orbit is not circular, since its radius of curvature changes due to the change in the magnetic field. A typical ion orbit is shown in each case.

Cyclotron, Synchrocyclotron and Synchrotron

Since 1930 many developments have taken place in this direction. The modern cyclotrons are huge and sophisticated machines, accelerating ions to energies of hundreds of million electron volts (MeV). The early cyclotrons could not accelerate ions to high energies; for example, protons could only be accelerated to 25 MeV. An ion, as it is accelerated to high energies, acquires a velocity approaching the velocity of light and therefore its mass increases according to the theory of relativity. This increase in mass results in the ion motion not being synchronous with the radio-frequency acceleration, and limits the maximum energy attainable.

In the synchrocyclotron this limitation is overcome by making the frequency increase as the ion acquires higher energies, thus maintaining the synchronous acceleration; energies of a few hundreds of MeV can then be attained.

In the synchrotron, the radius of the ion is kept fixed, and the magnetic field as well as the frequency are changed to maintain the synchronous acceleration. A synchrotron makes it feasible to achieve energies of many billion electron volts, required for elementary particle physics research.

Azimuthally Varying Field (AVF) Cyclotron

Further developments in nuclear physics highlighted the need for a high energy cyclotron which could give high yields of ions at precisely controlled and variable energies. The concept of alternate gradient focussing, also called strong focussing, made the development of such a cyclotron possible. Alternate gradient focussing implies the focussing of ions by making it pass through regions of strong and weak fields, appropriately arranged along the ion orbit. This requires an azimuthal variation of the magnetic field, as illustrated in figure 4. It is then possible to achieve isochronism at a given resonant, radio frequency, even at higher energies when relativistic mass increase is significant. The frequency and the magnetic field have to be appropriately varied to yield ions of different energies. Further, techniques have been developed to extract the beam from within the magnetic field with high efficiency. It is feasible these days to design a cyclotron giving protons of energy continuously variable from 10 MeV to 100 MeV, with external beam currents as high as 100 microamperes. The energy resolution of the beam can be made as low as 0.1%. Other ions can also be similarly accelerated. Simultaneously with the advent of azimuthally varying field (AVF) variable energy cyclotrons, many developments have taken place in the field of nuclear instrumentation and computors, and as a result, vast areas of reseach, requiring precise nuclear investigations, have been thrown open for the scientists.

Nuclear research with the modern cyclotron

The modern cyclotron is a versatile research tool, and offers promising opportunities of research in many fields. For the study of nuclear structure and nuclear reactions, it is an excellent machine. The different aspects that may be investigated are: elastic and inelastic scattering from nuclei, charged particle reaction such as stripping and pick up reactions, charge exchange reactions for the study of isobaric analogue states, polarization phenomena which lead to information on the nuclear spin orbit interaction, many body break up of nuclei which gives information on many body forces, fission phenomena, coulomb excitation, neutron induced reactions, and many other interesting phenomena. Further, production of neutron deficient radioactive isotopes using (p, n) reactions, is possible with a cyclotron.

In addition, there are other fields, such as solid state physics, atomic physics, nuclear chemistry, radiation damage, biophysics and astrophysical phenomena where the modern cyclotron can be utilized very well, by obtaining valuable information.

Variable Energy Cyclotron in India

The Bhabha Atomic Research

(Continued on page 8)

Stress on Support for IAEA's Positive Efforts

(Continued from page 1)

knowledge and experience available to all those who are interested in it. We have been very fortunate in our programme in having warm and friendly relations and co-operation with many countries. My distinguished colleague from Australia mentioned yesterday the details of the projects with which we are jointly involved. I wish to reciprocate our warm feelings to him about our common projects. So too, with the Philippines with which we have had a very successful project, known as the India — Philippines Agency Project.

Then there are the atomic energy commissions of many countries. I would name particularly Canada, France, the USSR, the UK and the USA who have actively collaborated with us in many areas and we cherish our relationship with them. In the field of nuclear power, we feel that there is a very big potential, as I will again discuss in detail this afternoon, and I would like to endorse a suggestion which has been made elsewhere that international organizations such as the U.N. Development Fund and the International Bank for Reconstruction and Development may well evaluate for themselves the scope of this important area for developing countries. I hope that the Agency's expertise would be available to these bodies to put the matter in the right perspective. I do feel that in many cases, financial considerations would be a serious impediment to the utilization of these new technologies.

Agency's Primary Role

I was listening with great interest to the statement of the Director General at this Conference yesterday. I must admit some concern about a particular quotation which I would like to read here :

> "When the NPT is in force there will have to be a shift of emphasis in the work of the IAEA. More weight will have to be given to the control functions. I hope that the Agency will still remain a technical organization, although it is inevitable that it will become much more exposed to the political situation in the world."

In another context, it has been mentioned, and I again quote :

> "...that the Agency's safeguards system would have to be adapted to the requirements of article 3 of the NPT."

I would like to express some concern that these sentiments should have been expressed, because the Agency's primary role has been clearly stated in its Statute and in its Articles, and the control function, which is an essential and a necessary function, is an adjunct to the more positive function of promoting the peaceful uses of atomic energy. I believe that one has to particularly safeguard the Agency's effort in the more positive directions, because without this, the regulatory function will become rather meaningless for the many countries which have still to taste the fruits of the benefits of atomic energy.

Sir, I would like to quote the relevant article in our Statute. It says :

> "In carrying out its functions, the Agency shall not make assistance to Members subject to any political, economic, military or other conditions incompatible with the provisions of this Statute."

In another connexion, it says:

> "The Agency shall allocate its resources in such a manner as to secure efficient utilization and the greatest possible general benefits in all areas in the world, bearing in mind the special needs of the underdeveloped areas of the world."

I do not doubt for a moment that you cherish all these things that are embodied in the Statute before us. But I would like to express my own personal view here that unless this Agency—and this will require self-restraint on the part of everyone—can make a conscious effort to reject the impinging of political pressures and political overtones into our activities, we shall wreck the very wonderful edifice which has been created with so much trouble over a long period of years.

The Agency's safeguards system certainly requires much reform, and we endorse efforts to this end. We hope that the document on safeguards for reprocessing plants will be brought in line with the revisions that have recently been done for the fuel fabrication document. It seems to me that the most important missing link in this whole chain of Agency documents on safeguards is the one relating to isotope enrichment. It seems to me that the efforts being made now to get detailed discussions on this subject are overdue, and I wish great success to the efforts, to see that we make progress regarding isotope enrichment. In the peaceful uses of atomic energy, I have no doubt that isotope enrichment will play a very useful and important role. Unless we tackle this problem before it becomes even more difficult, we are likely to be led into more complications.

No New Body Needed

The most important ingredient of the Agency's activities I would suggest are those provided in Article 3.1 which makes it very clear that all Agency services and activities are provided on request. I hope that in all the things we do we shall continue fully to maintain the spirit of this Article. I believe that the Agency is fully competent to undertake all services requested of it by those who signed the Non-Proliferation Treaty, and that there is no need for a new international body. Indeed, Articles 8, 9 and 10 in the Agency's Statute which refer to information on materials, and to services, equipment and facilities are fully comprehensive in our opinion and can already form the basis for providing all the services which one can think might be required to fulfil any of the obligations which those who have signed the Treaty require the Agency to provide for them.

India's Wholehearted Support to IAEA Activities

There has been a legitimate concern about the representative character of the Board, and we believe that there is reality in the feeling that the current situation reflects the need for some change or reform in the composition of the representation on this Board. We believe that it would be a legitimate exercise on which thinking would be required. I cannot help feeling that this is not going to be an easy process, because the considerations on which representation is given have been evolved after a great deal of negotiation and have stood the test of time. In the new thinking that we do, much would be gained by keeping some of these older principles still alive while providing a more enlarged representation. But I would suggest that this is something on which thinking could well begin.

Biggest Secret Out

The peaceful applications of nuclear explosions is a matter which has exercised much thought in recent times. About a month ago, when I was scientific chairman of an outer space conference here, I made the following observation, which I would like to quote. I said :

> "The military overtones of a satellite launcher development programme of course complicate the free transmittal of know-how of technology involved in these applications. But it is important to note a fundamental aspect of human development that knowledge cannot for long be contained within artificial boundaries and one has to learn and to control rather than control harmful effects through withholding transfer of technology or knowledge. After all, the biggest secret regarding the atomic bomb was let out when, through the demonstration of the explosion over Hiroshima, it became known to everybody that the device worked. Similarly, the biggest secret in space research became public property when the successful orbiting of the first Soviet satellite proved that this feat was possible. Thereafter, it is merely a question of time. Restrictions on the transfer of technologies which are involved in the peaceful uses of outer space merely jeopardise the security of the world through retarding the progress of nations. A physicist is trained to accept that what is not possible in theory is not realisable in practice. This elementary experience can well be applied in planning international systems for promoting the peaceful uses of outer space, as indeed also for peaceful nuclear explosions. Those systems that do not provide full participation by all nations in all aspects of technology in which they are competent to partake, are in my humble opinion not saleable, much less sustainable in the long run. Attempts to promote such systems merely poison international relations and the climate of co-operation".

I have quoted this because this is an aspect which I feel is a very fundamental one, growing from our understanding of science and technology. But I would like to say that I regard the Agency as the appropriate body to perform the regulatory functions which will undoubtedly be required for the conduct of peaceful nuclear explosions. I think, in this whole debate about the role of international agencies, one would have to distinguish the necessity of a regulatory body which would permit such exposions under a regime under either a partial or a complete test ban treaty and another agency which might assist nations on request to provide the services which are necessary. I would hope that more clarification on the subject consistent with the Agency's Statute will take place in the coming months and that we shall have a clearer idea of the lines on which this matter can be dealt with.

Resources Position

I come now to some observations on the Agency's Budget. To me, the resources position and the increasing responsibilities cause considerable anxiety, not because one is not willing to undertake them but because there doesn't seem to be a clearcut, explicit exercise undertaken at the Board level, to look at this problem in all its dimensions. It would seem to me that we might look at this problem for the next five years, because almost every atomic power station which is likely to be built during the next five years has already been committed now. One has a very clear idea of what is the magnitude of the problem which is likely to be faced during the next five years. It seems to me that one could define the alternative aspects of safeguards procedures which should be undertaken and estimate the relative cost of each one. It might be that one could arrive at a principle in which safeguards will be carried out at a certain level of operation on a normal basis, but that the Agency has the power and authority to conduct more detailed safeguards inspections, as may be required if the need arises, so that without burdening the Agency's budget and procedures with the required severity of safeguards inspections, one could leave a certain flexibility to the Agency inspectorate to undertake detailed inspections as required under certain circumstances.

Great Problems

I feel that a separate fund for safeguards organization of the Agency would be required, and that it would be equitable if contributions to this fund are made on the basis of installed nuclear power of nations rather than any other. One of the great problems that would arise if this is done on the basis of the normal budget would be that developing nations which are far from having nuclear power, would already start paying a contribution in terms of foreign exchange, for services which are not really originating from developments from which they have reaped the benefit. It would be more equitable if

(Continued on page 7)

Tarapur Will Generate Power from July

THE Tarapur Atomic Power Station is expected to begin continuous supply of power from July next year. Efforts however are being made to provide some power even earlier, by May/June. This was stated at a press conference in Bombay addressed by the Tarapur Project Administrator, Shri M. N. Chakravarti and the Director of the Bhabha Atomic Research Centre, Shri H. N. Sethna on September 30.

Explaining the causes of the delay in the Station's commissioning, Shri Chakravarti said that the target date for its completion, October this year, was less than 4½ years from May 1964, the date of execution of the contract for construction with IGE. This he said, should be viewed against the normal five-year period generally allowed for completion of a large nuclear power station. With the special pre-contract arrangements for this station, he stressed it could normally have been completed in a shorter period. However, as construction proceeded, a number of unanticipated difficulties cropped up. Among them were occasional labour disputes, the Indo-Pak hostilities which resulted in loss of key material and equipment in Pakistan, and strikes in the works of suppliers in the U. S. Despite these impediments, efforts were continued to bring the station to full power operation by the target date.

Systematic Check

Towards the completion of the construction phase of the work however, a systematic check of all components revealed certain minute imperfections in the furnace sensitized stainless steel material used in the Station. The defects were mainly confined to the reactor vessel and the tubes of the Secondary Steam Generator, he said.

To ensure trouble free and safe operation of the plant over its given life-time, such a thorough examination of all the components was necessary. Part of the delay in commissioning of the Station therefore could be traced largely to the stringent safety and reliability yardstick applied at every stage of the project. It was fortunate that the defects were detected at this stage.

The discovery of the imperfections was followed by a long period of investigation of all associated problems with supporting research work for arriving at an effective procedure for their removal. As similar defects have been noticed in the Oyster Creek Plant at New Jersey, U.S.A., Shri Chakravarti said constant contact was being maintained with the United States Atomic Energy Commission for working out the repair procedure. At the moment, round-the-clock work is going on under the supervision of experts from the International General Electric Co, the Tarapur Project, the Bhabha Atomic Research Centre, the consultants and the Lloyds Register, who are specialists in the field, to rectify the imperfections. And, to save time important replacements have been airlifted from the United States as against the normal way of shipping by sea.

Careful evaluation of the safety implications of the defects and the repair procedure has been made for ensuring that there is no compromise of safety or guaranteed output of the station. Shri Chakravarti also stated that the present repair work would not involve any payment on the part of the Government. Also, the delay in the completion of the Project would not lead to any increase in the cost of power except perhaps marginally due to interest during construction.

Answering questions, Shri Chakravarti and Shri Sethna said that the cost of the initial charge of fuel obtained on a deferred payment basis from the USAEC was $ 14.365 million. The increase in costs of the Station attributed to the delay would be negligible, confined primarily to increased interest during construction, including interest on fuel. These would no doubt affect power cost but only marginally, about 0.1 paise per kWh. The cost of power from the Station however, they maintained would be fully competitive with conventional thermal power in the region.

IAEA Address

(Continued from page 6)

those who are reaping the benefit from the peaceful uses of atomic energy had this as a charge. It would be a small one, which would not make a significant difference to the economic picture of that particular benefit.

I am very glad that the Agency is now exploring the possibility of obtaining analytical and other services which it requires, from various national agencies. I was sorry to learn from the Director General's comments that the response had not been very satisfactory, and I would hope that more national laboratories in various parts of the world would come forward to provide to the Agency, analytical and other services, which would reduce the burden on the Agency's budget.

Technical assistance, I still believe, is one of the most important and positive aspects of the Agency's activities, and we feel that unless some way is found for providing more technical assistance rather than less, as has been happening during the last few years, there is no immediate possibility of a large number of developing nations really getting into this field. At Tarapur we have been having trainees from a large number of countries who have come to see the starting of operations, and I would like to offer here similar facilities which we hope to provide also in the irradiation of food.

It is a pleasure again to pledge a voluntary contribution of $ 35,000 in non-convertible rupees to the Agency, and I would like to close sir, by pledging my nation's wholehearted and complete support to the Agency and all its activities, and wish you well in the years to come. ●

Mystery X-Ray Stars

(Continued from page 2)

may well be some link between the X-ray source and the birth as well as the death of stars.

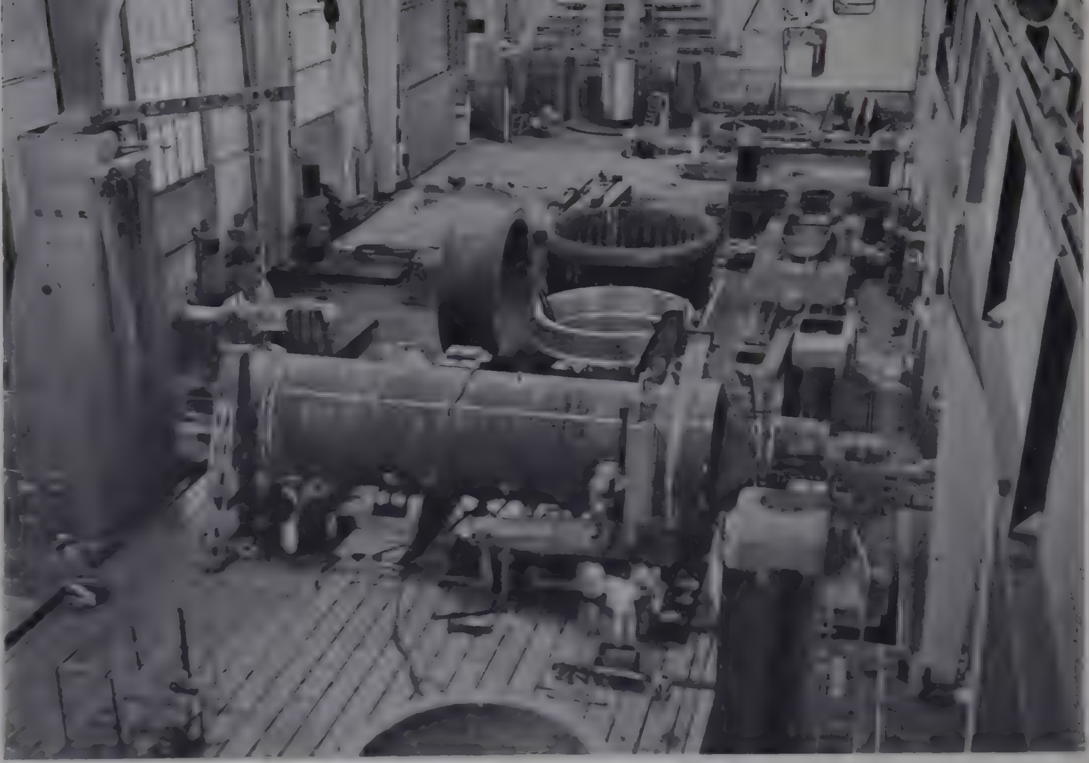
At the moment there are too many theories and not enough facts, but the facts are beginning to come in. One important field of X-ray astronomy is concerned with the Sun, a relatively weak but conveniently close source. Eight Skylark rockets, launched from Woomera, have already carried X-ray telescopes trained on the Sun. The American Orbiting Solar Observatory, OSO-4, launched last October, carried an X-ray telescope contributed by University College, London. Another similar instrument travelled on the first British satellite, Ariel 1, and another British instrument will be orbited when the next attempt is made to launch the first European satellite, ESRO 2. An elaborate British X-ray telescope will travel on the third American astronomical observatory when this is launched. The next all British satellite, Ariel 4, may carry an array of X-ray telescopes. *(Courtesy SPECTRUM No. 49/1968.)*

Electromyograph

(Continued from page 1)

tween the life sciences and engineering, for it involves the study of motor unit action potentials by interpretation of bio-electric data derived through sophisticated electronic techniques. The application of the EMG to clinical investigations includes location and diagnosis of certain muscle and nerve abnormalities, detection of progress in nerve regeneration, plotting of strength-duration (S-D) curves for the study of progressive nerve lesions, and follow-up studies, identifying myogenic and neurogenic disorders, study of biophysical characteristics in vivo and in vitro of nerve tissue etc.

Since July, it has been undergoing clinical tests at the Post Graduate Research Laboratories of the J. J. Group of Hospitals, Bombay.



Machining of reactor pressure vessel for the first Dutch nuclear power station at Dodeward.

Holland's First Atomic Power Station

EARLY this year, the reactor of Holland's first nuclear power station was lowered on to its foundation near Dodewaard on the northern bank of the river Waal

The nuclear part of this 50,000kW station which has a boiling water type reactor, was designed by the General Electric Company of the United States.

The reactor is designed to produce steam at the rate of 256,000 kg/h. The steam, on leaving the reactor, has a temperature of 286°, at a pressure of 70 bars or 71.36 kg. per sq. cm.

The steam/water separation is effected at the surface of the water. The steam first passes a steam drier mounted underneath the cover of the reactor, then proceeds directly to the turbine and finally collects in two condensers connected in parallel. The condensed water from the condensers flows via ion exchangers to four preheaters connected in series, from where it is returned to the reactor.

To prevent the reactor water in the vessel from being contaminated by corrosion products, a purification system is installed which has a capacity of 17 tons of reactor water per hour.

The reactor vessel is designed for a life of 40 years. To ensure adequate protection against corrosion, its wall is lined inside with a thin layer of stainless steel. ●

Cyclotron at Calcutta

(Continued from page 4)

Centre will be building an AVF Variable Energy Cyclotron at Calcutta during the fourth Five Year Plan period. The Saha Institute of Nuclear Physics at Calcutta will collaborate in this project. This cyclotron is designed to produce 6-60 MeV protons, 12-65 MeV deuterons and 25-130 MeV alpha particles, with an external beam current of 100 microamperes. The design follows the design of the cyclotron at the Texas A & M University, College Station, which in turn follows the design of the 88-inch cylotron at the Lawrence Radiation Laboratory of the University of California at Berkeley, U.S.A. The cyclotron will be built indigenously, only the very basic components being imported. The approximate cost of the project will be about Rs. 5 crores. ●

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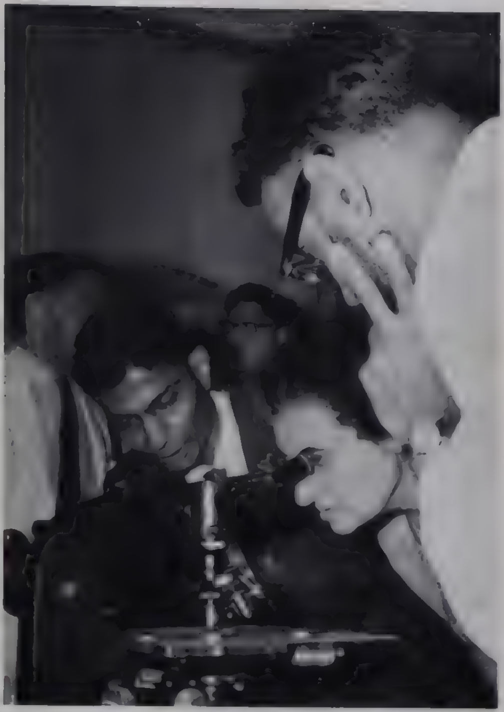
~~The~~ 1036-capacity Homi Bhabha Auditorium at the Tata Institute of Fundamental Research.



Smt. Indira Gandhi in the TIFR Laboratory.

An Auditorium Named After Homi Bhabha

ONE more idea of Homi Bhabha's came to fruition on November 9 when the exquisitely designed and built Homi Bhabha auditorium was inaugurated by the Prime Minister, Smt. Indira Gandhi at the Tata Institute of Fundamental Research, Bombay.

One of the tangible entities that Bhabha left unfinished, the 1036-capacity auditorium reflects the elegance and close attention to detail so characteristic of him.

Dedicating the building to the scientist's memory, the Prime Minister recalled her father's and her own close association with him. The life of a politician, she explained, full of glamour from outside, lacks the sensitivity which others take for granted. For her father, she said, Homi Bhabha opened a window of sensitivity, "a window to a relaxing and entirely new world." "To my admiration for Dr. Bhabha was added a warm affection for the friendship he gave my father and which I knew meant a great deal to him."

Continuing, she observed that a man was judged by the width of his mental horizon and, Dr. Bhabha, she felt, was a man who bridged generations, old and new, West and East. He was equally at home in the world of science and arts. Indian science, she maintained, owed much to him. Indeed, the whole of India, she said, owed him much. The Tata Institute, the national centre for nuclear science and mathematics, she said, was a living tribute to the great scientist. It had grown in stature, had developed a fine team of dedicated scientists and was a living proof, that "India can do it."

Art, Mrs. Gandhi stressed, was just as important to man as science for, without art, there could be unfolding of the human being only to the extent that it spoke to that person. When one talked of science in India, she explained, it meant not only experiments and their application to technology, but changing the outlook of the people, widening their horizons and making them learn to seek new paths. People faced many problems, she said, mostly age-old ones of poverty and economic backwardness. Some of the others were of tradition and superstition and, added to them were those which came out of development, growth and change. But perhaps the greatest problem, she said, was that of "changing faster."

Changing the methods of work and modes of thinking was necessary not only among those who were illiterate and who did not have the privilege

(Continued on page 2)

'Most Creative Indian Born in this Century'

(Continued from page 1)

of higher education, but also among those who had that privilege. "Even more specially to the world in India, which is still living many centuries behind and still has a very long way to go before she can provide the good things of life, or even the necessary basic things to most of her people," she observed.

What lifted Dr. Bhabha above the rest? It was his vision of the future, his faith in India's future, said Mrs. Gandhi. It is only with that vision, that faith, she said, that we can mould the future of the country. The most lasting memorial to Dr. Bhabha could only be that "we keep alive his spirit, keep alive his vision and faith and work with his versatility."

Astonishing Versatility

Earlier, Shri J. R. D. Tata, Chairman of the Council of Management of the Tata Institute said that outside the field of politics, in which he took no interest, Dr. Bhabha was the greatest and most creative Indian born in this century. The creator and builder extraordinary that he was, Shri Tata said, Dr. Bhabha had taken great interest in the building of the Institute, "itself a work of art in its functional efficiency, scientific achievement and aesthetic quality." Continuing, he said it was a matter of perpetual surprise to him that "this man of astonishing versatility had managed to bestow so much time, love and energy" on the Institute. The legacy of "this great Indian that we cherish today," he said, was the elite of scientists. Shri Tata closed his speech with a quotation from Dr. Bhabha: "Ideas are some of the most important things in life and men are prepared to suffer and die for them. Good ideas cannot be suppressed, even by violence. Nothing is irreversible except death, this is my philosophy of life."

Speaking after Shri Tata, Prof. M. G. K. Menon, Director of the Institute, said that the completion of the auditorium was symbolic of the determination of the Institute to complete many of the other tasks that Homi Bhabha had left unfinished, many of them intangible. These tasks, he said were not personal, or routine ones. They were on behalf of the Institute, on behalf of the development of science and on behalf of "this country which he deeply loved." He recalled how, on January 23, 1966, just a day before Dr. Bhabha left, he had spent several hours at the Institute and talked at length to him about the many things that needed to be done in the country rapidly. Dr. Bhabha had felt that the Institute had grown to maturity in the two decades of its existence. He was also convinced, Prof. Menon maintained, that the problem of establishing science as a live and vital force in society was an inseparable part of the problem of transforming an industrially underdeveloped country to a developed one. Dr. Bhabha was beginning to feel increasingly the need to develop what Jawaharlal Nehru was so fond of referring to as the scientific temper in the country. In this context Prof. Menon recalled a quotation from Dr. Bhabha which gives an insight to his thoughts: "I wish we could provide more of the good things of life for members of our Institute and indeed, the people of our country."

Welcoming the guests, Dr. P. V. Cherian, Governor of Maharashtra payed tribute to Dr. Bhabha as the man whose foresight and efforts had put India on the world map of nuclear science. If the country had made substantial progress in the peaceful uses of atomic energy, Dr. Cherian said, it was in no small measure due to the vision and drive of the late Dr. Bhabha. Shri V. P. Naik, Chief Minister of Maharashtra said the Tata Institute had rendered great help for the advancement of learning in India.

The auditorium made its debut that evening with the first lecture of the Homi Bhabha Lecture Series, by Nobel Laureate and an Honorary Fellow of the Institute, Professor C.F. Powell, on "The Aims and Role of Science in our Time", and the opening of an exhibition on Dr. Bhabha conveying a visual impression of his multi-faceted personality. This exhibition contained original paintings and drawings, the personal creation of Homi Bhabha in the visual arts, as well as photographs, with quotations on and by him, depicting various aspects of events in his life; also on display were some of the original letters written a quarter of a century ago, which formed the basis for the setting up of the Tata Institute of Fundamental Research and the beginning of the Indian Atomic Energy programme. ●

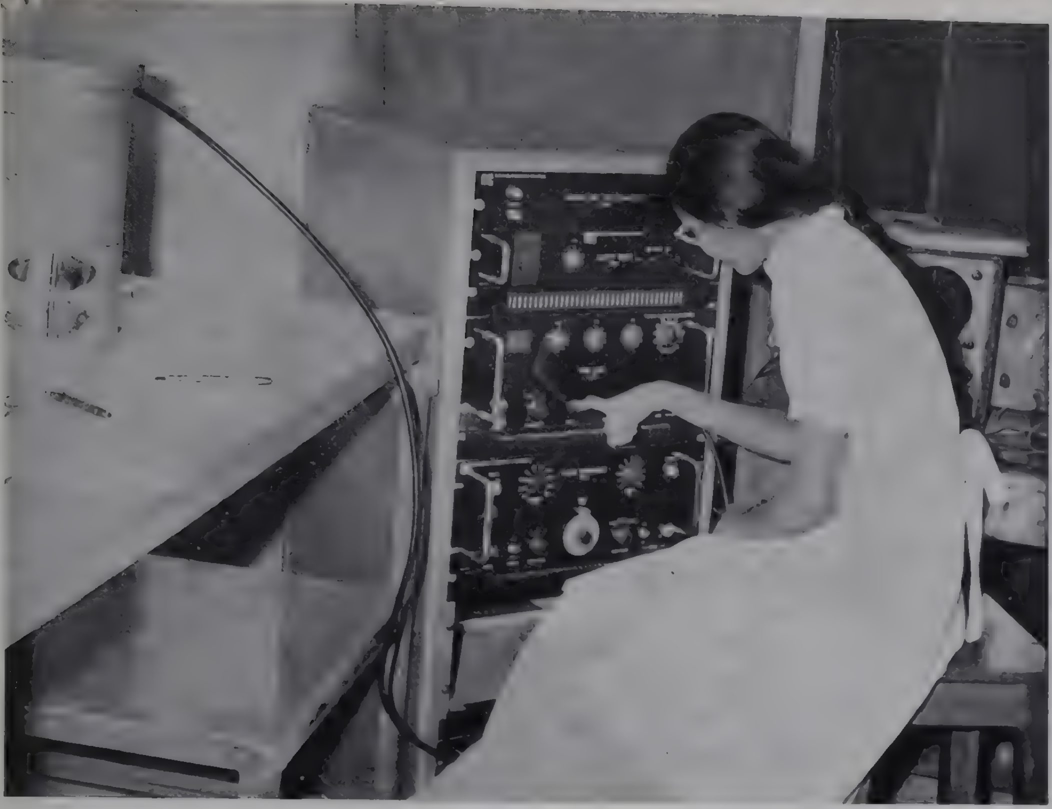
'In Itself a Work of Art'

AN original part of the Tata Institute building plan, the imposing auditorium was taken up only after completion of the first phase of building activity *i.e.* the laboratories, library, workshop, canteen, offices etc.

Equipped with a simultaneous translation system which enables the use of the floor plus four other languages, the auditorium is ideal for international conferences, seminars etc. The complete system for simultaneous translation was fabricated by the Electronics Division of the Bhabha Atomic Research Centre which also built the dimming system, for controlling light intensity.

Dr. Bhabha had felt that an auditorium with a capacity of 1,000 seats would not be used by the Institute throughout the year for its own scientific and educational activities. He had therefore made some modifications in the area of the stage to enable the auditorium to be used for music, dance, drama and film shows. The auditorium thus is an amenity to the city of Bombay for cultural organizations which may wish to utilize it

(Continued on page 3)



A trainee at the Radioisotope Centre measuring the strength of a radioactive source.

Hyderabad Isotope Centre Inaugurated

A RADIOISOTOPE Centre was inaugurated at the Hyderabad Science Society, Hyderabad, by the Director of the Bhabha Atomic Research Centre, Shri H. N. Sethna, on October 24.

A non-government body, the Society has set up the Centre with financial aid from the Department of Atomic Energy. Equipment for it was provided by the Isotope Division of the Bhabha Centre and the Electronics Corporation of India Ltd., Hyderabad.

The next day, October 25, a six-week training course, the first of its kind to be organized by a non-official body in India, commenced at the Centre. The course, which is being conducted with the assistance of the Isotope Division, provides instruction in both the theoretical and practical aspects of radio-isotope techniques. A total of nine participants from various industries, research institutions and universities in the neighbourhood of Hyderabad are participating in it.

Inaugurating the Centre and the training course, Shri Sethna said the contribution of radio-isotopes to science and technology and in alleviating human suffering was immense. Speaking of medical applications in India, the Director mentioned that about 10,000 patients were being administered with radioisotopes, And, radioisotope therapy was proving beneficial to around 4 to 5 lakh people every year, he said.

One of the significant developments in recent years, he observed, was the use of ionising radiations for preservation of perishable food products and for the sterilization of medical supplies. In fish industry alone, he said, in some areas losses ran as high as 25 to 30 per cent of the annual production. Isotopes could help reduce these staggering losses by decreasing perishability during storage and transport, he maintained.

The Director disclosed that the Bhabha Centre had carried out tracer studies of silt movement in several ports and harbours of the country to plan dredging operations in an effective manner. A major radio tracer investigation, he said, would shortly be undertaken at Vishakapatnam, in connection with the outer harbour project, for studying the pattern of movement in and around the site.

The function was presided over by the Chief Minister of Andhra Pradesh, Shri Brahmananda Reddy. ●

Bhabha Auditorium

(Continued from page 2)

whenever it is not required by the Institute itself.

Attached to the auditorium is a Museum Area for exhibitions, art shows etc. For the Institute, this area is useful for portraying important activities relating to research and development as also latest scientific results obtained at the Institute and elsewhere in the world in the areas in which it is interested.

Important Interface

There is an increasing need to bring science closer to the people as part of science education at all levels and for developing a scientific temper in the nation. The facilities that exist for this in the country and in the city of Bombay are at present limited. In this respect, the Homi Bhabha Auditorium may constitute an important interface of the Institute with the outside where, through regular programmes of lectures and exhibitions, it will be possible to convey to the public a picture of what is being done in the Institute, and thus carry science into society. When not used by the Institute for exhibitions on science, the Museum area may be used for exhibitions of paintings, sculpture, etc. which might be of interest to the Institute in a broad sense.

The first exhibition to open in the Museum area, appropriately, is on Homi Bhabha. It is similar to, but on a larger scale than the one arranged at the Royal Institute in London in January 1967, on the first anniversary of his death. ●

Nuclear India

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Space Res

On November 20, 1963, the first rock
Station at Thumba. With this launc
space studies acquired a new dimens
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THE scientific study of meteorology and of the variations in the earth's magnetism was started more than a century ago in India. Both these fields are related to solar activity and to influences transmitted through the upper atmosphere extending, as we now know, upto about 50,000 km in the direction of the Sun and more than 4,00,000 km on the dark side beyond the orbit of the moon. Till the advent of the space age, the characteristics of the region above the ceiling altitude of balloons could only be inferred from ground experiments. With rockets, satellites and deep space probes, direct observations in outer space became possible for the first time. These have illuminated the whole field in a dramatic way, leading to the discovery of new phenomena, the substantiation of some of our old ideas and the rejection or a drastic modification of many others.

With a long established tradition of research in meteorology, ionospheric physics, geo-magnetism, cosmic rays, astrophysics and solar physics, India has a good scientific base and a deep interest in the exploration of outer space. Moreover, such exploration gives an opportunity to Indian scientists to participate in activities of great practical significance in the fields of meteorology, communications, navigation and geodesy.

Magnetic observations commenced in India in 1841 at Simla, Bombay, Madras, and Trivandrum. Among the important contributions may be mentioned the discovery in 1858 of the 27-day periodicity in the daily variation of the geomagnetic field by Alan Broun at Trivandrum, the study of lunar and luni-solar variations by Chambers, and of time variations of the magnetic field during magnetic storms by Moos at Bombay. The Survey of India organised field observations for preparing magnetic maps of India in 1902. Observations both in India and elsewhere revealed unexpectedly large daily variation of the magnetic elements near the geomagnetic equator, which has since been attributed to the presence of a narrow current sheet called "Equatorial Electrojet" in the upper atmosphere.

The equatorial electrojet, a concentrated zonal flow of electric current which occurs above the magnetic equator in the region of 90-130 km presents many interesting problems in aeronomy, particularly problems dealing with the interaction of neutral and charged particles in the presence of the earth's magnetic field. Special features arise from the fact that the magnetic field of the earth is exactly horizontal at the magnetic equator.

A solar physics observatory was started at Kodaikanal in 1899. Among the notable contributions made by the Kodaikanal Observatory in astrophysics are the discovery of the outflow of gases above sunspots (Evershed effect), the confirmation of the shift of spectral lines, and the discovery of near infra-red oxygen lines in the solar chromosphere and prominences. In theoretical astrophysics, the researches of Meghnad Saha on the ionization of stellar atmospheres and of S. Chandrasekhar on stellar dynamics and other fundamental problems have been outstanding.

The high value of the earth's magnetic field and the possibility of conducting experiments at high altitudes close to the geomagnetic equator has stimulated experimental cosmic ray research. Carl Compton in 1936 and Robert Millikan with Neher and Pickering conducted crucial experiments with balloons to investigate the possibility of a banded structure in the energy spectrum of the primary cosmic ray intensity. Bhabha's work on the interpretation of the cascade showers observed in cosmic rays and high energy phenomenon in the interaction of fundamental particles was followed by the establishment by him at the Indian Institute of Science, Bangalore, in 1940 of a small experimental unit which was the fore-runner of the Tata Institute of Fundamental Research (TIFR) at Bombay. Active schools of cosmic ray research grew in the late Forties at the Bose Institute, Calcutta and the Muslim University at Aligarh. Sarabhai's work on the time variations of cosmic rays and their relationship with the oscillation of the atmosphere led to a cooperation with Ramanathan in the field of aeronomy and to the establishment of the Physical Research Laboratory (PRL) at Ahmedabad in 1948. Ramanathan's extensive studies on the vertical distribution of atmospheric ozone and its relationship to atmospheric circulation; the discovery of the 11-year periodicity in the daily variation and the day-to-day variation of the anisotropy of cosmic ray intensity and their relationship with inter-planetary electro-magnetic conditions by the group at the Physical Research Laboratory; and work on the energy spectrum and composition of cosmic rays, the discovery of negative K-capture and Tau-decay and the development of a wide base of experimental techniques by the group at the Tata Institute of Fundamental Research are amongst the major contributions by India in this field. A large experimental set-up in the Kolar Gold Fields to measure cosmic ray neutrinos of both terrestrial and extra-terrestrial origin; the extensive air-shower measurements at Ooty; the set-up of radio

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lia's over a hundred-year-old tradition of
is article reviews the space research acti-
arly days upto the present.

interferometers at Kalyan and a large cylindrical radio telescope at Ooty also form a part of the activity of TIFR. Extensive geophysical investigations include study of cosmic ray-produced isotopes and investigations on very heavy nuclei using meteorites.

Beginnings of Space Research

The TIFR Bombay has carried out more than 100 major flights, from Hyderabad with plastic balloons, since 1959. The balloons, fabricated locally, are made of special quality polyethylene film and their volumes have ranged from a fraction of a million to 3 million cubic ft. They are capable of flying payloads upto 250 kgs. The large balloons can reach ceiling altitudes close to 36 km and float at that altitude for about 8 hours. A number of interesting experiments can be carried out near the geomagnetic equator and generally in low latitudes where only very high energy cosmic ray particles are admitted into the earth's atmosphere. Hyderabad has a well equipped equatorial balloon facility, established by the Tata Institute of Fundamental Research, which has been widely used by research groups from the Physical Research Laboratory, Ahmedabad, and the United States Air Force Cambridge Research Centre and for an extensive international collaborative programme during the International Quiet Sun Year (IQSY) in 1965.

The experiments being conducted by these groups involve the measurement of the composition and the energy spectrum of primary cosmic radiation, including the electron component, investigation of neutrons emitted from the Sun, study of cosmic X-rays and gamma rays. The study of the characteristics of high energy measurements have been extended upto about 150 KeV by the scientists at TIFR using improved magnet-emulsion chambers having a permanent magnet giving a field of about 3,000 gauss.

Special types of large area plastic films have been flown by the Geophysics group of the TIFR in an attempt to record relativistic cosmic ray nuclei of charge greater than 30. Sophisticated experimental payloads with elaborate orientation systems and line twisters have been fabricated by the groups at the PRL and TIFR to study the flux, energy spectrum and time variation of X-ray fluxes from discrete sources and to investigate the characteristics of the isotropic background X-rays which are of metagalactic origin.

The possibility of tracking satellites has given us a new tool to explore natural phenomena. The optical tracking of satellites at the Uttar Pradesh State Observatory at Nainital, in collaboration with the Smithsonian Observatory of Harvard, has made it possible since 1958 to conduct satellite geodetic studies in India. The satellite telemetry receiving station at PRL, Ahmedabad which was started in 1961, in collaboration with NASA, has made it possible to receive the data of the Solar X-ray flux from various NRL satellites and radio beacon data from S-66 satellites.

The Radio Propagation Unit of the National Physical Laboratory, Delhi commenced in the early Sixties a study of ionospheric propagation using the radio beacon transmissions from Soviet satellites. Theoretical work was also commenced on the structure and composition of the atmosphere.

Indian National Committee for Space Research (INCOSPAR)

In August 1961, the subject of exploration of outer space for peaceful purposes was allocated to the Department of Atomic Energy. The Indian National Committee for Space Research was constituted by the Department of Atomic Energy of the Government of India in early 1962 under the Chairmanship of Dr. Vikram A. Sarabhai.

Quite early, INCOSPAR decided to establish a sounding rocket range on the geomagnetic equator at Thumba, near Trivandrum in South India. It consciously laid emphasis on creating facilities which would permit a study of problems in aeronomy in the region upto 200 km. which is below the operational level of satellites. It was felt that this would be particularly appropriate, since the programme could be conducted with small sounding rockets involving a modest budget. Moreover, the scientific results would have a direct bearing on a better understanding of meteorology which is of great practical significance to the Indian economy.

Amongst the autonomous laboratories related to the Department of Atomic Energy and largely supported by it, is the Physical Research Laboratory with a major emphasis on basic research in the fields of aeronomy, cosmic rays, interplanetary space and solar activity. The principal responsibility for setting up the new activity, in consequence, naturally fell on the scientific personnel of the Physical Research Laboratory, and in October 1963 the administrative charge for the Thumba establishment was formally entrusted to the Physical Research Laboratory. Through this, Dr. Bhabha was following a precedent which had worked very successfully in the early stages

(Continued on next page)

of the Atomic Energy programme, in which the Tata Institute of Fundamental Research played a major role. Moreover, through the administrative charge being carried by an autonomous laboratory which was at the same time closely related to the Department, overall coordination by Government along with the flexibility of an academic type of institution was ensured.

Thumba Equatorial Rocket Launching Station (TERLS)

In 1963, a site was selected on the west coast of India, 16 km. north of Trivandrum in the State of Kerala for the establishment of an Equatorial Rocket Launching Station. The site is 40 km. south of the geomagnetic dip equator.

The sounding rocket programme was initiated in November 1963 by collaborative agreement with NASA, which provided rockets for the initial series of experiments and important major range equipment such as a radar, a telemetry and a DOVAP ground unit. The range was further developed through collaborative agreements with CNES of France, which provided Centaure rockets and a radar, as well as with the Hydrometeorological Services of the USSR, which provided a computer, a helicopter and a shake table. At the same time, for an on-going programme with sounding rockets, an agreement was concluded for the supply of manufacturing know-how with Sud Aviation in France for the local manufacture of Centaure rockets. The responsibility for initially fabricating the rockets according to this know-how was entrusted to the Bhabha Atomic Research Centre at Trombay. A facility has been set up at Thumba to make solid propellants for rockets and a new establishment to fabricate sounding rockets is coming up by its side.

The Thumba Equatorial Rocket Launching Station has received U.N. sponsorship as an international range and has an Advisory Panel consisting of India, the host country, France, USA and USSR.

Up to June 1968, 31 meteorological sounding rockets reaching an altitude of 60 to 70 km and 34 two-stage rockets reaching an altitude of between 120 and 180 km have been launched from TERLS. Experiments have involved scientific groups from India, France, USA, W. Germany, Japan and the USSR.

Experimental Satellite Communications Earth Station (ESCES)

A most important practical application of space research is the use of satellites for telecommunications. When a satellite is in a circular equatorial orbit at a height of about 35,900 km the earth appears stationary to it and a large part of a hemisphere is visible to it. Two widely separated points in the area of visibility can establish high quality reliable telecommunication links through the "synchronous" satellite. A communication satellite can also be used for the dissemination of television pictures over a wide network of T. V. receiving stations.

To enable India to gain competence in global satellite communications, the Experimental Satellite Communications Eath Station has been established at Ahmedabad by INCOSPAR with assistance from the U.N. Special Fund. An important objective of ESCES is to train scientists and engineers of India and of other developing countries to enable them to make use of satellite communications. The heart of the equipment at ESCES is a large parabolic dish, 14 metres in diameter which collects the weak signals transmitted from satellites. These are then amplified by low noise microwave amplifiers and processed to extract the information. A modest beginning in space communication was made in late August 1967 when ESCES successfully transmitted and received messages and television pictures from NASA's ATS-2 satellite and established contact with Japan

Satellite television can be a very powerful tool of mass communication and for promoting national integration. Its use, particularly in popularising new methods to increase agricultural productivity, in promoting general education and in disseminating information about population control is of great significance. To demonstrate convincingly its advantages, a pilot project was jointly undertaken in January 1967, by the Department of Atomic Energy, All India Radio, the Indian Agricultural Research Institute, and the Delhi Administration. A programme reaching 80 villages around Delhi through community receiving sets and promoting the use of modern agricultural methods has been undertaken. Experience gained so far indicates that a qualitative change of great relevance to the developmental process of isolated communities is possible.

The parabolic dish of the Experimental Satellite Communications Station, Ahmedabad.

Space Science & Technology Centre (SSTC)

In 1965, the Atomic Energy Commission approved a proposal of INCOSPAR to establish a Space Science and Technology Centre with major responsibility for developing sounding rockets of superior performance and for acquiring expertise in aero-space engineering and scientific payload construction for rockets and satellites. The Centre was also to provide back-up support to space research through ground based experiments. The Space Science and Technology Centre (SSTC) has been set up at Veli Hill, by the side of TERLS. A large group of engineers has been assembled at the SSTC to work in different disciplines of rocket technology such as propellant engineering, propulsion, structural engineering, aerodynamics, materials engineering and quality control, control and guidance, technical physics, electronics, mechanical and systems engineering. The first India-made rockets of the Rohini RH-75 series were successfully flight-tested in November 1967.

Automatic Picture Transmission System (APT)

A most interesting practical application of space research arises from new meteorological inputs. Since the oceanic area forming three quarters of the globe, as well as the uninhabited land terrain are not covered by meteorological observations, weather prediction has been very difficult. Orbiting meteorological satellites of the TIROS, NIMBUS and ESSA families, now provide observational platforms in space from which large areas of the earth's atmosphere are scanned and the information is transmitted to stations on the ground. These satellites, which are equipped with Automatic Picture Transmission Systems (APT) can take and transmit cloud pictures every 208 seconds with high resolution infrared radiometer cameras. Such pictures, covering an area of about a million sq. km. of the earth's surface are received by meteorological stations in different parts of the world, including the APT receiving station at the Meteorological Centre, Colaba, Bombay. The information received is disseminated to all the forecasting offices of the India Meteorological Department thus enabling meteorologists to infer weather systems over areas of sparse observations over land and sea. Operationally, they are useful for the issue of cyclone and storm warnings, for aircraft flight briefings and in aiding navigation of ships. Satellites cloud pictures thus obtained reveal the existence of two belts of cloud maxima in the equatorial zone of the Indian Ocean even in July, separated by a region of minimum cloudiness at the equator.

This observation has important consequences on our understanding of the Indian Southwest Monsoon.

Satellite Geodesy

Good navigation requires an accurate knowledge of the distances between various points on earth. Geodesy deals with the geometry of the earth and the force of gravity. Observations of satellites provide data on the time variations of their orbital parameters. The computation of the distances of the various points of the earth's surface from its centre and the gravitational acceleration at these points from the above orbital data constitute satellite geodesy.

For the last ten years, the Uttar Pradesh State Observatory (UPSO) at Nainital has been participating with the Smithsonian Astrophysical Observatory (SAO) of the United States in a cooperative programme of optical satellite tracking. The data from Nainital and the other eleven co-operating stations have been used to compute the precise gravitational field of the earth, its shape, and the cartesian coordinates of the twelve stations with respect to the centroid of the earth with an accuracy of about 15 metres. For example, the coordinates of Nainital are 1,018,205 metres along the meridional plane containing Greenwich, 5,471,100 metres eastward from it, and 3,109,614 metres northward. The corresponding values determined by purely land survey measurements are 1,017,912; 5,470,401 and 3,109,385 metres. The data also show that the mean sea-level off Trivandrum is ninety metres nearer the earth's centre than that off Singapore and 140 metres nearer the centre than the sea-level off Dover, in the English Channel.

Plans are afoot for setting up a satellite tracking station in Trivandrum with more modern equipment. It is expected that data collected there would help in the determination of the coordinates of South Indian stations with a precision of about 10 metres. The coordinates of island stations like Minicoy and Port Blair not connected to any land survey grid can be in error by as much as 500 metres. When satellite tracking stations are set up on these, their coordinates also can be determined with a precision of about 10 metres.

Research in Aeronomy

Many rocket-borne experiments have been designed and carried out from Thumba to supplement our meagre knowledge of the dynamics and composition of the upper atmosphere at equatorial latitudes. The payloads include those for releasing vapour clouds to measure winds in the neutral atmosphere, electron-ion probes and plasma noise probes for the study of the nature of the ionosphere, U.V. detectors and ion mass-spectrometers to measure the composition of the ionosphere, magnetometers to investigate the electrojet, and chaff to measure winds in the mesosphere.

Measurement of winds in the neutral atmosphere between 30 and 60 kilometres have been carried out with a series of Judi-Dart rockets by the India Meteorological Department and TERLS using chaff payloads. Tracking radars have been utilised to follow the drift pattern of the chaff, consisting of thin copper coated mylar filaments, released from these rockets.

Valuable data on wind velocities, shears and regions of turbulence along the vertical, in the neutral atmosphere from an altitude of 80 km through the E region upto 180 km have been obtained by the scientists from the Physical Research Laboratory (PRL), by analysing photographs of clouds formed by the release of sodium and self-luminiscent vapour from the rockets. Many of these experiments have been performed in collaboration with the U.S. and French scientists. These studies have been supplemented by a collaborative study with German scientists of the visible cloud of barium-ions, the drift velocity of which provides information about the electric fields in this region. The chemical composition of the neutral atmosphere has been investigated jointly by scientists from USSR and PRL, using a Radio Frequency Mass Spectrometer.

Many payloads of electron-ion probes, plasma noise probes and U. V. detectors have been fabricated and flown in rockets by the PRL scientists. Detailed electron density and temperature profiles of the ionosphere, particularly in the region of the electrojet, have been obtained from these flights.

The equatorial E_2 layer was found

(Continued on next page)

Space Research in India

(Continued from page 7)

to be associated with high electron temperatures. The plasma noise was measured in the frequency range 70 to 1 KHz and this study will be of great value for the study of the interactions of neutral gas and ionospheric plasma. Plasma noises were detected in the regions 85 to 105 km, 142 to 155 km and 155 to 173 km. The plasma noise in the first two regions is likely to be genuine while that in the third is produced by the rocket itself.

Since 1964, Proton Precession Magnetometers have been flown on rockets by scientists from the U.S.A. and later by the PRL scientists for investigating the structure, extent and the movements of the current systems in the equatorial electrojet. The results obtained so far have shown that the equatorial electrojet current has a maximum intensity of about 5 amperes per sq. km at a height of about 105 km above Thumba.

The conventional technique of the investigation of ionosphere, namely the ground-based ionosonde, does not give detailed information concerning the region below 150 km except in the region near the E region maximum. Since the satellites orbit only above 200 km, small sounding rockets seem to be the only means of direct probing of this interesting but complex region of the ionosphere.

The D region of the ionosphere may be considered to extend from about 50 km to 95 km (base of the E region). The region is characterised by low electron density and high collisional frequency. The region is a principal attenuating region for a passing radio wave. The base of the ionosphere with the concentric conducting surface of earth forms a lossy wave guide that is responsible for the propagation of low and very low frequency radio waves. The potentialities of very low frequency radio waves for standard time transmission and reliable worldwide communications are now recognised. Thus a proper understanding of the absorption of radio waves and the propagation of low frequencies is essential for optimum utilization of radio frequency spectrum for communication and other services. For this purpose, a detailed knowledge of the structure (electron density *vs* height profiles) and the time variation and the height distribution of collisional frequency is required.

An experiment with rocket-borne cosmic noise receiver connected to a dipole antenna to make a set of measurements on (I) positive ion density and electron density profile in the D region, and (ii) solar ionising flux in the lyman-alpha and the X-ray flux regions has been proposed by scientists from National Physical Laboratory (NPL), New Delhi.

On March 17, 1967, the rocket experiment was successfully conducted by an NPL scientist from Wallops Island, USA.

Radio Astronomy

An extensive programme to pursue studies in radio astronomy has been undertaken both at the TIFR and at PRL. The studies at the TIFR are centered around (1) a radio antenna array consisting of 32 dishes each of 1.82 m. diameter set up at Kalyan (48 km. from Bombay) to study radio emission from the Sun and (2) a large cylindrical radio telescope under construction at Ooty in South India. The telescope at Ooty is about 500 metres long and 30 metres wide and will be used mainly to study distant radio galaxies in our universe by the moon-occultation method.

The programme at PRL incorporates the spectral and polarization studies of solar radio bursts at metre wavelengths. A radiometer to measure solar flux at decimeter wavelengths is being set up. A 110 Mc/s "total-power" radiometer has been set up to record scintillations of radio stars for studying ionospheric irregularities. The 14-metre parabolic dish at ESCES will also be used for studying problems of galactic radio-astronomy.

X-Ray Astronomy

The discovery of celestial X-ray sources in 1962 opened up a new field of astronomy. Many of the X-ray sources do not show any emission in either the optical or the radio regions even though they emit X-rays copiously. Besides the descrete sources, a continuous background of omni-directional X-rays has also been discovered at the top of the atmosphere. It has been suggested that the background flux is of metagalactic origin.

The basic study of X-ray astronomy involves the determination of the position, the extent, the total flux, the energy spectrum and the time history of different X-ray sources. The optical identification of the source, wherever possible and its association with the X-ray emission are of extreme importance to the understanding of the nature of these celestial objects. Most of the experiments conducted so far have primarily made a good survey of the northern part of the celestial sky and hence it is very important to extend this to the southern sky.

A cooperative project in X-ray astronomy was undertaken in April 1968 by scientists from the Physical Research Laboratory, Ahmedabad and from the Institute of Space and Aeronautical Science, University of Tokyo. Joint rocket experiments carried out by these groups have concentrated on the determination of the flux and the energy spectrum of the SCO-X-1, Centaurus-X-2 and TAU-X-1 sources besides a general survey of the southern celestial sky. Simultaneous optical observations of the SCO-X-1 source at both the Kodaikanal Astrophysical Observatory and at the Tokyo Astronomical Observatory are conducted to discover the relationship between the optical and the X-ray emissions. The series of experiments beginning with the first two rocket flights in April 1968 are intended to keep a close watch on the time variation of the X-ray emission from SCO-X-1 over a period of a few years. ●

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Bombay Seminar on Radiation Protection

A five-day Regional Seminar for Asia and the Far East on Radiation Protection Monitoring concluded on December 13 at the Tata Institute of Fundamental Research, Bombay. Sponsored by the International Atomic Energy Agency and the World Health Organization, the Seminar was attended by 78 scientists from 12 countries in the region. India, the host country, was represented by 49 scientists. In addition, ten experts from some advanced countries also attended by special invitation.

A system of monitoring or checking to protect workers against harmful levels of radiation is an essential part of the safety programme in nuclear plants and laboratories. The Seminar enabled participants to exchange experiences and results of studies in many aspects of this field. Special attention was given to radiation detecting and measuring equipment, their calibration and maintenance, and effects of climatic and local plant conditions on their performance. Instruments for use under emergency conditions were also discussed.

Fifty Papers

In addition, lectures were given on methods of radiation measurement, interpretation of results, sources of inaccuracy, recommendations of the International Commission on Radiological Protection etc., by specialists invited by the two sponsoring organizations.

In all about fifty papers were presented at this seminar. Besides, invited review papers on various aspects of radiation protection were presented by Dunster (U.K.), Wachsmann (Germany), Pychlau (Germany), Unruh (U.S.A.), Ishihara (Japan), Hayodom (Thailand), Francois (France), Subrahmanian (India), Yeabsley (New Zealand), Cowper (Canada), Gangadharan (India), Yudin (USSR), Nachtigall (Euratom), Karamourtzounis (WHO) and Meilland (WHO).

The Seminar was inaugurated on December 9 by Dr. S. Chandrasekhar, Union Minister of State for Health, Family Planning and Urban Development.

Dr. Chandrasekhar said that radiation hazard was one of the problems arising out of rapid expansion in the uses of radiation in various scientific and technological fields. Scientific advances made during this century had added man-made sources of radiation to the existing natural ones in the environment. In recent years, he stated, the situation had been made more complicated by the contamination of the atmosphere by radioactive fallout. This steady rise in environmental radiation, whether it was used for medical care, industry, science, technology or for research purposes, and the consequent contamination of the air, soil, and water of this planet was a matter of concern to all, particularly since the undesirable effects of uncontrolled radiation affect the health of the whole community, the population of the world and, what was worse, even the unborn generations of all living beings. It was imperative, he said, that this challenge be met with adequate research and needed information on the

The Chairman of the Atomic Energy Commission, Dr. Vikram Sarabhai, speaking at the Seminar. Others in the picture are, from left: Mr. G. Swindell (IAEA), Mr. G. Dorofeev (IAEA), Dr. S. Chandrasekhar, Minister of Health, Family Planning and Urban Development, Prof. I. S. Zheludev, Deputy Director General, IAEA, Mr. J. N. Karamourtzounis (WHO) and Mr. W. Dominiak (IAEA).

(Continued on page 7)

BARC Reporting

Waste Treatment Division

Air filters produced in the Pilot Filter Production Unit of the Division were issued for use in Radiological Laboratories, Plutonium Plant and other facilities of the Centre. These filters have replaced the imported ones so far used by these facilities.

The production cost of the filters is Rs. 31,300. The total cost of equivalent imported filters would be Rs. 91,500 with a foreign exchange component of Rs. 48,100.

Directorate of Radiation Protection

During November 1968 the countrywide film badge service covered a total of 7,800 workers from 967 institutions.

The Advisory and Planning Group tendered advice to 25 institutions on problems of radiation safety and in the planning of radiation installations. A total of 19 institutions in the country using radiation sources were surveyed by BARC experts to determine the adequacy or otherwise of radiation safety measures in vogue in these institutions.

Isotope Division

A total of 439 consignments of radioisotopes valued at Rs. 61,284 were exported to Australia, Denmark, France, Taiwan and Thailand, during Nov./Dec. '68. Special mention may be made of the export of a 5,000 curies Panoramic Irradiator to Taiwan.

A radiotracer study was started at the Vishakapatnam Outer Harbour project to study the pattern of silt movement on the sea bed in the project area. Two lots of scandium-46, 25 curies each, have been used for these studies. The movement of the tracer on the sea bed is being followed with underwater detectors.

CYCLOPS 3

At Britain's National Physical Laboratory an enthusiastic team of scientists from several different disciplines are busy learning how to talk to computers. Today's computers have to be addressed in their own language, one of the complex computer codes. But, if we ever build true robots, we will want to talk to their electrical brains in ordinary speech. At the National Physical Laboratory, it is said, the psychologists and engineers in the Autonomics Division, led by Dr John Parks, have already devised a machine which would be able to read neat human handwriting, a big step beyond today's reading machines, which can only tackle regular print.

CYCLOPS 3, as the machine is called, doesn't exist as yet as hardware; it is only a computer model. But the computer programme which represents it is so accurate and complete that it has been possible to test every aspect of the working of Cyclops without having to build it. The machine could be built tomorrow, but the scientists concerned will probably hand over the actual construction of Cyclops 3 to another team in one of the big electronics firms, while they go on to develop an even better machine, Cyclops 4.

Cyclops 3 is the descendant of two earlier print-reading models, Cyclops 1 and 2, and although it works on the same general principles as these machines, Cyclops 3 has certain added features. It has a single scanning aperture, hence the name, but this viewing device has several different scanners, arranged in a row. The machine scans each letter in a word in turn. The first stage is to place a sort of map grid over the letter and then to break the continuous line of ink up into a number of different short sections. Each of these sections is then allotted its position reference, with vertical and horizontal co-ordinates. Its slant is also roughly measured.

Looking for Four Things

The machine makes a mental note of all this data and then takes a second look at the letter. This time it scans the letter looking for four things, ends of lines, points where two lines cross over, T-junctions, and bends and curves. The numbers and relative positions of these are also noted.

Finally Cyclops has to allow for the varying size of letters in handwriting; a problem which doesn't arise in reading print. It does this by either scaling up or scaling down its mental picture to a regular size, the same size as its own built-in library of letters. Finally it compares its mental picture of the letter under examination with the whole library, which is made up of circuit patterns, each corresponding to one letter of the alphabet. The one which corresponds best is identified by Cyclops 3, as the letter under examination.

Fascinating Fact

This process only takes about a thousandth of a second. One feature of Cyclops is that it can deal with imperfectly written letters — it can weigh up the probability of a messy piece of handwriting being meant to be a B or an A. It does this by taking a look at a whole section of the print simultaneously and interpreting its all-over impression, and this is something in which all the three models of Cyclops excel over any other reading machines built anywhere else in the world. And a fascinating fact which has been discovered at the National Physical Laboratory, where they are combining their attack upon computer language with an inquiry into brain mechanisms, is that this is how the brain apparently handles vision. At the Laboratory, Dr. Christopher Evans has carried out experiments in which subjects look at a simple diagram of a cross inscribed inside a circle, while a brilliant flash bulb is let off. Then they close their eyes and look at the after image on the retina. Instead of

(Continued on page 3, col. 1)

disappearing gradually and piecemeal, first one whole arm of the cross, then another, then two of them disappear, always in complete units. Dr Evans believes now, with much experimental evidence to back him up, that this indicates that the brain builds up its picture out of discrete elements and that these correspond to rows of living cells in the brain, which somehow scan and identify lines and other features in the scene presented by the eye, just as Cyclops' linear viewer scans writing. Ultimately Dr Evans hopes to learn from the eye itself to help in the design of future reading machines. (*Reprinted from SPECTRUM No.* 52, 1968.)

TIFR Colloquium On Cosmic Rays

NEW and exciting developments which have taken place during recent years in cosmic ray research on the one hand, and Astronomy and Astrophysics on the other, have demonstrated the existence of important connections between these apparently different areas of basic research. It has been found furthermore that these connections and links play a vital role in bringing a better understanding of our universe. To focus attention on these aspects, a six-day Colloquium on "Cosmic Ray Studies in Relation to Recent Developments in Astronomy and Astrophysics" was organised by the Tata Institute of Fundamental Research, Bombay, during November 11-16, 1968.

The important topics discussed at the Colloquium included (i) the chemical abundances of nuclei in the cosmic radiation and their relevance to nucleosynthesis in explosive celestial objects such as supernovae, (ii) cosmic ray electrons and their connection with radio astronomy, (iii) the production, propagation and confinement of charged cosmic ray particles in cosmic space, (iv) cosmic X and gamma rays and their importance in astrophysics and cosmology, (v) Quasars and Pulsars, the recently discovered celestial objects, and their relevance to cosmic rays, cosmology etc. and (vi) neutrinos in astrophysics.

Six Indian and eight foreign scientists lectured in the Colloquium; while the Indian scientists dealt mostly with the many advances made in cosmic ray research, the foreign scientists covered relevant topics in astrophysics, astronomy and cosmology. A special feature of the colloquium was that about half the working time was devoted for panel discussions so that overall perspectives could be identified and emphasised. The colloquium also provided an opportunity for diverse viewpoints of experts in different disciplines to bear upon problems of mutual interest. ●

Award for Trombay Thorium Plant

THE Thorium Plant at Trombay, which is managed by Indian Rare Earths Ltd., for and on behalf of the Department of Atomic Energy was awarded the First Prize by the Council of Industrial Safety, Bombay, for the highest percentage of improvement in the frequency rate of accidents among factories working one-million man-hours or less in a year.

The plant was erected by Indian Rare Earths Ltd. to French design and went into production in 1955. In the 13 years of its operation, it realized approximately Rs. 1.75 crores in foreign exchange and nearly Rs. 3.2 crores by internal sales of thorium nitrate. The plant has also supplied considerable tonnage of uranium fluoride to the Bhabha Atomic Research Centre. The fact that this plant has maintained improvement over its frequency rate of accidents is creditable considering that it is 13 years old and handles concentrated acids, alkalis of varying concentration and radioactive thorium and uranium.

It will be recalled that last year, Indian Rare Earths Ltd. was given the ICMA (Indian Chemical Manufacturers' Association) Award for Outstanding Performance in the export of a product of the chemical industry. ●

Answers in Parliament

TERLS

A Centaure two-stage rocket with an X-ray astronomy payload was launched from Thumba on November 3, 1968. The payload, air-borne instrumentation and electronic timer were all developed indigenously.

The scientific objective of the experiment was to measure the X-rays sources and to find out new sources of X-rays by surveying the Southern sky.

The results of the experiments will be freely available to the international scientific community.

(*Lok Sabha, November* 20, 1968)

Indian Rare Earths Ltd.

Foreign exchange to the extent of Rs. 94.04 lakhs was earned by the Indian Rare Earths Ltd. from export of rare earths chlorides to countries in Europe, USA and Japan during 1967-68.

The following steps are under consideration for increasing the export of rare earths during the next three years: (i) reduction in the cost of production, (ii) separation of individual rare earths to the extent economically advantageous, (iii) diversification, (iv) modifying the quality of the product to suit the consumer's needs and (v) the establishment of personal contacts with the large consumers of rare earths products.

(*Lok Sabha, December* 11, 1968)

Uranium Dioxide Fuel

The Department of Atomic Energy has decided to establish facilities for producing enriched Uranium Oxide Fuel elements for use in the Tarapur Atomic Power Project. The detailed project reports in respect of these facilities are under preparation.

The plants are likely to cost about Rs. 150 lakhs and will be established at Hyderabad along with the Nuclear Fuel Complex.

(*Lok Sabha, December* 18, 1968)

Radiation Protection in

SINCE the ushering in of the atomic era, radiation sources are being used in various applications in agriculture, industry, medicine and research. This in turn has led to the balance of environmental radiation being disturbed by the constant release, into the environment, of a wide variety of radioactive effluents. Fortunately, however, radiation health and safety measures have kept pace with the rapid progress made in the atomic energy field. Thus the safety record of world-wide atomic energy operations has indeed been an excellent one.

Radiation health and safety measures call not only for the proper design and construction of radiation installations in order to maximize built-in safety, but also for the regular monitoring of both radiation areas and radiation workers in order to ensure that specified radiation levels are not exceeded.

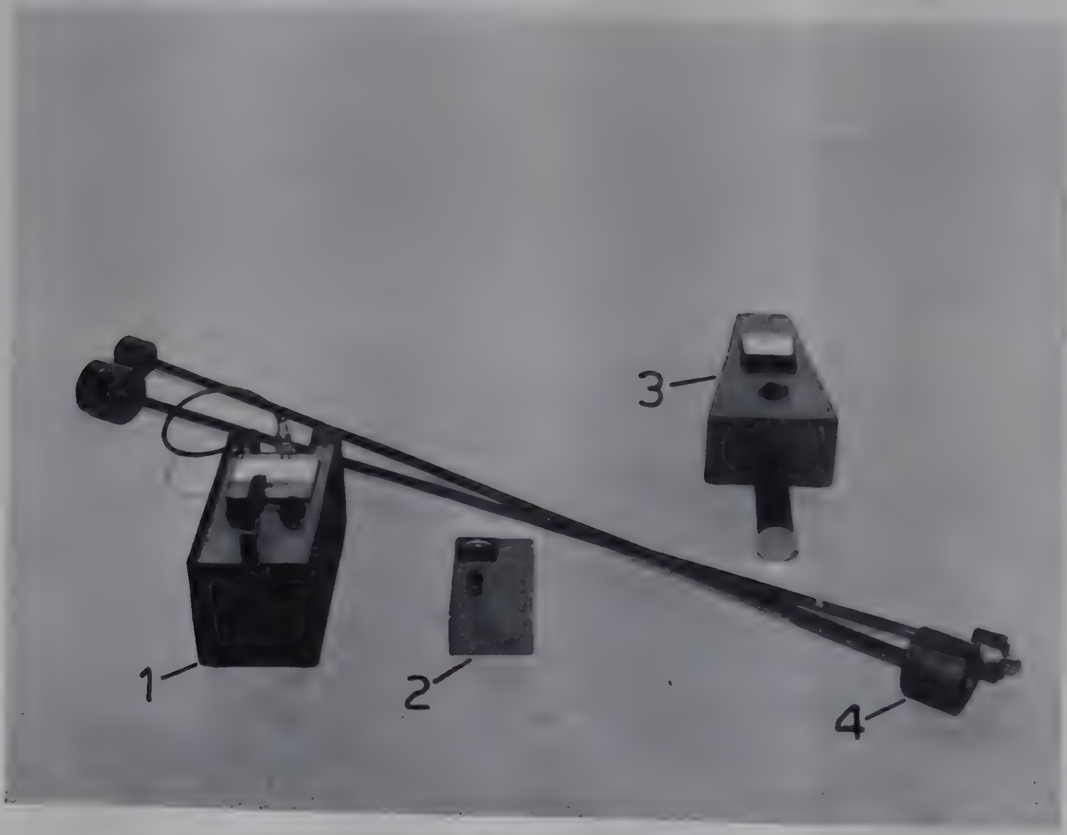
In India, the responsibility for radiation protection lies with the Bhabha Atomic Research Centre at Trombay. This work is handled by the Centre's Health Physics Division and the Directorate of Radiation Protection.

The scientists of the Health Physics Division look after the radiation health and safety aspects in the Centre and at the various nuclear projects under the Department of Atomic Energy. The safety aspects of other projects in the country in which use of radiation is involved, is the responsibility of the Directorate of Radiation Protection.

The Health Physics Division carries out its task through three units: (i) the Air Monitoring Section, (ii) the Body Burden Measurement Section, and (iii) the Radiation Hazards Control Section.

The Air Monitoring Section conducts studies for detecting and monitoring levels of radioactive fallout resulting from nuclear weapons tests, and carries out research on aerosol physics, atmospheric chemistry and on low-level counting techniques. The fallout and nuclear weapons' tests detection programme is carried out through 11 monitoring stations distributed all over India. The Section's monitoring studies also include the measurement of radiation levels in food. Samples of foodgrains, milk, vegetables, soils etc. are collected from time to time and assayed for radioactivity.

(1) A portable beta gamma contamination monitor (2) a small compact pocket type radiation monitor (3) a wide-range survey meter which can be used with extension rods (4) for use in high radiation fields.



Micrometeorological studies are also conducted by this section through stations set up at Trombay and at the power reactor sites at Tarapur, Kotah and Kalpakkam.

Extensive field experiments have been conducted for gathering data on atmospheric diffusion characteristics at power reactor sites in India and, on the basis of this data, rules have been formulated regarding maximum rates of radioactive discharges, exclusion distances etc.

Indigenous Instruments

In all these studies, there is need for extremely sensitive and sophisticated nuclear electronic instruments and the section has designed and fabricated a variety of instruments for its special needs. These include air monitoring systems, multi-channel analysers, low-level counting systems, a microbarograph for the detection of nuclear weapons tests, sensitive anemometers with photo-electric choppers, thermistor probes for air temperature measurements, wireless data telemetry systems for short range transmission of meteorological data and transistorised data logging syssystems. Some of the instruments designed and fabricated at the Bhabha Atomic Research Centre are shown in these and following pages.

Studies on natural radioactivity in food and in the environment as well as problems in solid state radiation dosimetry are undertaken by the Body Burden Measurements Section. This Section is also involved in the development, fabrication and maintenance of electronic instrumentation associated with such studies. It has developed various types of whole body counters. Some of these systems are al-

TLD System. The entire system, except the balance and the recorder (top right), has been developed in BARC laboratories.

ready in routine use at the Uranium Mine and Mill at Jaduguda and at Trombay.

Health and safety services for the various installations in the Centre and the constituent units of the Department of Atomic Energy are provided by the Radiation Hazards Control Section through four groups, namely the Operational Physics Group, the Industrial Hygiene and Safety Group, the Analytical Chemistry Group and the Biological Studies Group. The Operational Health Physics Group looks after the overall health physics work at the reactors, production plants and the various laboratories at Trombay on a round the clock basis. These services also cover the various other atomic energy facilities at Bombay, Alwaye, Jaduguda, etc.

This group of scientists has also undertaken duties such as filter testing, radon and thoron monitoring, health physics indoctrination of plant personnel, and health and safety services for field experiments involving radioactive tracers.

In addition, it has undertaken the planning of health and safety measures for the Tarapur Atomic Power Project, and made several safety evaluations on problems connected with power reactor design and operations. It also operates a Central Radiation Emergency post at Trombay.

Environmental Surveys

The Industrial Hygiene and Safety Group provides advisory services in conventional industrial health and safety matters and, in collaboration with the Medical Division, operates an accident prevention programme.

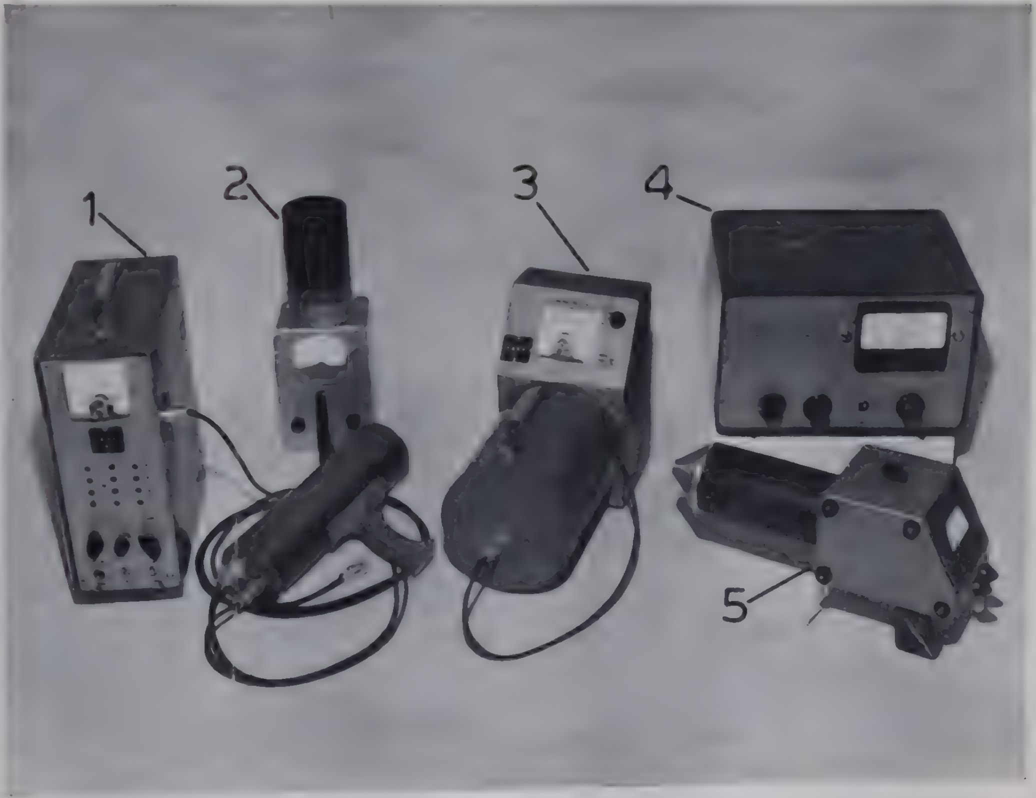
The Analytical Chemistry Group conducts bioassay, environmental monitoring and effluent analysis at Trombay. It is further responsible for preoperational environmental surveys at the power reactor sites. Environmental surveys are conducted upto a distance of 48 km. around operational sites and the effluent laboratory maintains a close check on all environmental discharges.

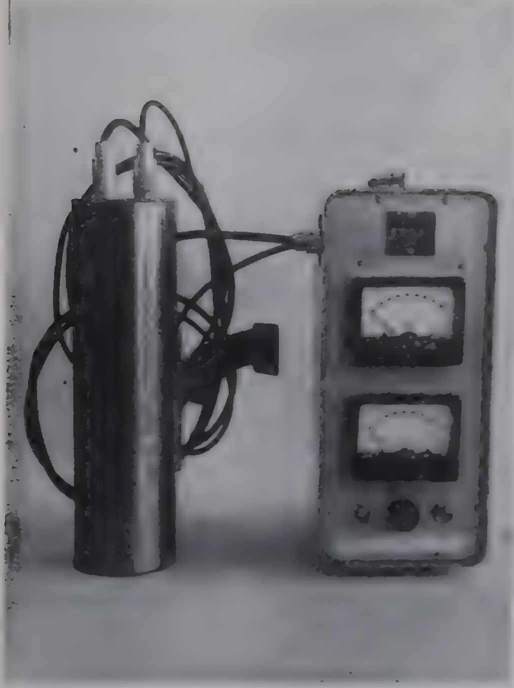
The Biological Studies Group is engaged in an extensive study of the distribution of radioactivity in the marine environment. The study includes uptake of radionuclides by marine organisms, biological concentration factors, sediment transport etc. An extensive programme in this area was recently conducted by this group in association with the IAEA.

The Research and Development Group is engaged in development and applied physical research work. Studies on the build-up of radio-

(*Continued on page* 6)

1. A fast neutron monitor with scaler. 2. an ion chamber type survey meter. 3. a neutron flux meter. 4. an isotope calibrator and, 5. a scintillation type survey meter.





Scintillation type fast neutron monitor. This portable monitor with scaler has been developed for field use.

activity during reactor operations, criticality computations, and fission product decay characteristics are some of the activities of the group.

Other services undertaken by the Radiation Hazards Section include the development, maintenance and calibration of health physics instruments and the development and fabrication of protective equipment such as plastic suits and respirators etc. All requirements of plastic suits and air respirators as well as dust respirators for BARC and other units of DAE are being met by the Health Physics Division.

Responsibilities of DRP

Besides the activities of the Department of Atomic Energy, there are a number of projects and medical, agricultural and industrial establishments, located all over the country where radiation sources are employed. To cover all such units, the Directorate of Radiation Protection is charged with the responsibility of organizing a countrywide radiation protection programme under the Atomic Energy Act of 1962.

The tasks undertaken by the Directorate include: (a) organization of a countrywide personnel monitoring programme for radiation workers, and the maintenance of appropriate individual dose records; (b) initiation of appropriate measures in cases of excessive exposures of individuals; (c) organization and conduct of radiological protection surveys of institutions using radiation sources; (d) formulation and promulgation of rules and regulations relating to radiation protection; (e) education of radiation workers in the safe use of radiation sources; (f) design and development of radiological instruments and protective devices; (g) setting up of safety standards and the publication of radiation safety manuals; (h) research and development on various aspects of radiation measurements and radiological hazards; (i) advising institutions on the layout of radiation installations such as X-ray and teletherapy installations and radioisotope laboratories and on problems relating to the transport, storage and use of radiation sources; (j) advising on civil defence measures to be initiated against nuclear attacks; and (k) the initiation and execution of appropriate measures in cases of radiation emergencies.

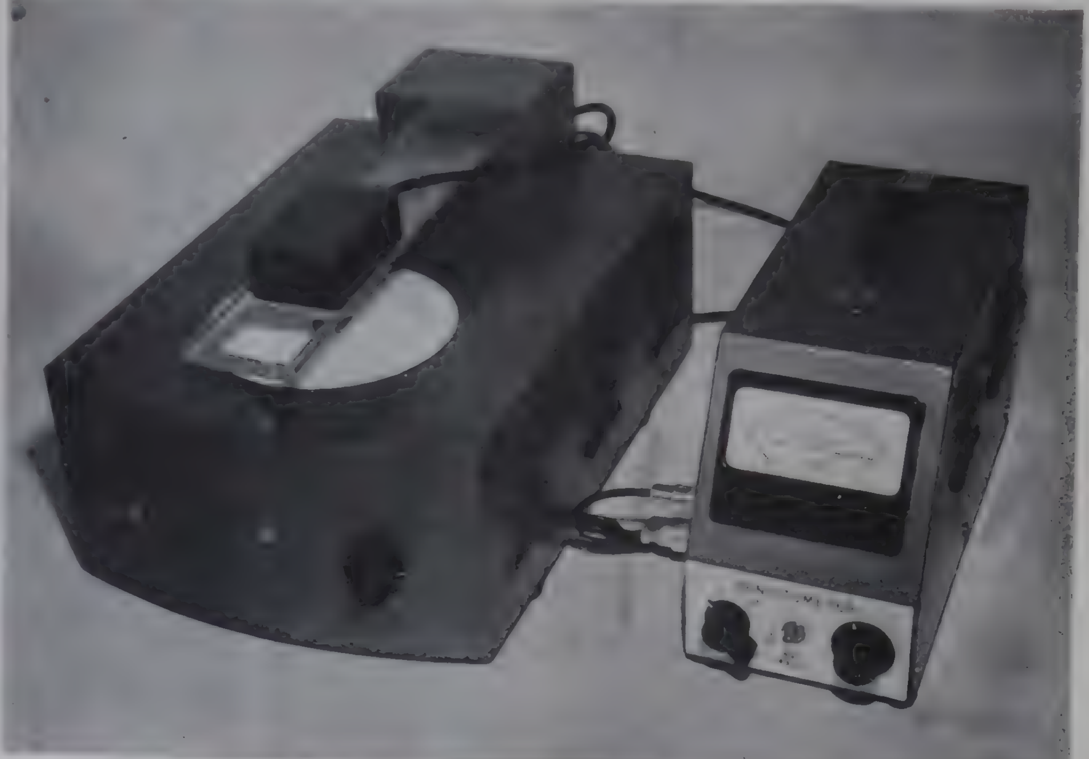
During the past few years, nearly 250 persons from all over India have attended the Directorate's short-term courses on medical uses of radiation and associated safety measures. Approximately, the same number of persons have attended similar courses on industrial uses of radiation.

In addition, for the past seven years, the Directorate has been conducting, in cooperation with the World Health Organization, a one year post-graduate course in Radiological Physics aimed at training persons in the use of radioactive sources in medicine, industry, agriculture and research, and in implementing attendant safety measures. Apart from scientists and engineers from South East Asian countries, more than 100 trainees from India have successfully undergone the course. They have been made available to hospitals, industries and research institutions where radiation sources are employed. As these persons have also been trained in all aspects of radiation safety, the implementation of a countrywide radiation safety programme has been rendered very much easier.

Countrywide Coverage

The Directorate conducts a countrywide film badge service covering nearly 13,000 radiation workers from about 1,100 institutions. Besides, it also conducts research and development work on chemical dosimeters, glass dosimeters, thermoluminescent dosimeters and dosimetric systems

Densitometer developed for the measurement of optical densities of photographic films.



Contamination monitor. This portable, battery powered monitor is made entirely of indigenous components.

based on foil threshold detectors. A considerable amount of work has been done in the dosimetry of intense radiation fields in the megarad range.

To meet the needs of the programme, the Directorate has developed and built a wide variety of instruments, most of them specially suited for work under the widely varying climatic conditions encountered in field use. Some of the instruments developed by the Directorate include densitometers for measuring densities of films used in radiation measurements, thermoluminescent dosimetry systems, contamination monitors (both with and without scalers), wide range survey meters and small pocket type radiation dosimeters. In addition, a

Clinical dosimeter. This dosimeter is primarily useful for intracavitory dose measurements.

(*Continued on page* 8)

Regional Seminar at Bombay

(*Continued from page* 1)

fundamental and applied aspects of nuclear radiation.

Continuing, he said that the essential pre-requisite in situations of "unexpected" hazards, was an awareness of the nature of the hazard. This took one to the problem of education and training of workers in the field. Radiation protection today, he stressed was no longer a sophisticated scientific discipline confined to Health Physics, but an important and growing field of Prevention and Social Medicine.

The Legal Aspect

During the past few years, Dr. Chandrasekhar stated, there had been a growing feeling that the legal aspects of radiation hazard needed more careful consideration. The problem was complex and essentially linked up with the knowledge of 'cause and effect' relationship between the quantum of radiation exposure and the statistical incidence of its deleterious effects. Dr. Chandrasekhar expressed the hope that knowledge would grow in this field and that scientists would be in a position to guide in the matter. The future, he said, belonged to nuclear energy. The development and application of nuclear science had been one of the major fields of activity where international collaboration had played a very significant role.

Reviewing work in this field in India during the last 20 years, the Minister said that the country had contributed in its own way towards the peaceful uses of atomic energy. This progress, he stressed, was made possible by combining "our own talents with international collaboration in the field."

A New Situation

Welcoming Dr. Chandrasekhar, Dr. Vikram A. Sarabhai, Chairman of the Atomic Energy Commission said that the military uses of atomic energy had produced a qualitative difference in the security of the world and in international relations. With the break-through that had recently occured in technology related to the peaceful uses of atomic energy, particularly in the field of power generation, he said, a qualitatively new situation had developed which would affect all nations.

In India, Dr. Sarabhai continued, active steps had been taken by the Atomic Energy Commission under Dr. Bhabha for a national programme of radiation protection at the very beginning of its work. Apart from the 'in-house' service for programmes and projects of the AEC, he stated, there was now a nation-wide coverage through the Directorate of Radiation Protection. Ten years ago, the service was used by barely 100 radiation workers in the country. Today, nearly 13,000 workers in more than 1,100 institutions were covered. He said, it would have been impossible to undertake a responsibility of this magnitude without most of the instruments and devices being available locally. Research and development on a major scale undertaken at the Bhabha Atomic Research Centre, he said, had resulted now in large scale manufacture of instruments at the Electronics Corporation of India Ltd. The instruments and devices were particularly suitable for rugged operations under tropical conditions.

Man-Made Additions

Dr. Sarabhai added that since radiation was ever present in the environment from naturally occurring radioactive substances and isotopes artifically produced by cosmic rays, an aspect of radiation protection which was of great importance was to study the implications of man-made additions to the background to which life is usually subjected. The background of course, he said, differed widely in different areas of the country, such as, for example, the shores of Kerala, where radioactive monozite sands are abundant. Marine life and vegetation selectively concentrate certain radioactive substances. Extensive studies were being conducted, he added, on the natural environment sur-

(*Continued on page* 8)

Bombay Seminar on Radiation Protection

(*Continued from page* 7)

rounding major atomic energy installations in the country, particularly the atomic power plants, and through a nationwide network of stations for monitoring aerosols and fallout from the atmosphere.

Earlier, welcoming the delegates, Professor Ivan Zheludev, Deputy Director General for Technical Operations of the IAEA stressed the need for effective radiation control to ensure safety in nuclear work places.

Professor Zheludev recalled that soon after the discovery of X-rays and radium more than 60 years ago, it was recognized that radiation could cause severe damage to living tissues. In view of this and the long time that might elapse before some of the ill effects appear, it was absolutely essential, he said, that the development of a programme for the peaceful uses of atomic energy be accompanied by the development of an effective radiation control programme.

IAEA Standards

He considered the maximum possible dose established by the International Commission on Radiological Protection (ICRP) as "an example of good sense in international affairs and obviously of help to the growth of international cooperation in the development of atomic energy." They are now accepted as a basis for regulations throughout the world.

IAEA has issued its own Basic Safety Standards for Radiation Protection which conform to the ICRP recommendations. These standards, he said, called for the need to assess the doses which workers may incur and to check the working conditions. Various efforts of the Agency to help its Member States in developing effective monitoring programmes have included the publication of manuals and handbooks and through the organization, sometimes in collaboration with WHO and other international organizations, of conferences on such topics as the assessment of radioactivity in man, personnel dosimetry for radiation accidents, neutron monitoring, and assessment of airborne radioactivity. Three regional study group meetings have discussed radiation protection monitoring in addition to other nuclear health and safety problems.

Professor Zheludev revealed that the Agency might issue in the near future several publications on personnel dosimetry systems, monitoring of the working environment, and calibration facilities for monitoring instruments. A symposium on new developments in radiation detectors has been proposed for 1970 and intercomparison of calibration facilities is being organized. ●

Ammonia Molecules Discovered in Space

SCIENTISTS at the California University, USA., report discovery of ammonia molecules in the vast hydrogen clouds at the centre of the Milky Way galaxy.

The finding is the first ever of a relatively complex chemical substance in interstellar space.

The discovery, published in *Physical Review Letters*, was achieved with a radiotelescope tuned to the microwave "fingerprint" of ammonia.

Ammonia, composed of nitrogen and hydrogen (NHE) is readily formed on earth under a variety of conditions.

It was detected in the clouds of the constellations Sagittarius (Archeh), a typical region of gas and cosmic dust which scientists believe is the "incubator" of new stars.

The discovery is of enormous speculative interest because ammonia substances have been proposed by many authorities as the chemical precursors of organic compounds, and a key link in the long progression to more complex molecules and life itself on earth.

A team headed by the Nobel Laureate, Dr. Charles H. Townes (father of the laser), of the University of California at Berkeley, reported the work. They employed a new radio telescope and ultra-sensitive receiving equipment located at the University's observatory near Hat Creek, California.

It was Dr. Townes who led the initial study of the ammonia spectrum at Columbia University in the 1940's work that led directly to the first laser (gas laser) and the laser itself.

Previously astronomers from `the same university discovered the HO (Hydrogen-Oxygen) radical in space. The radical is so-called because it is the base on which other atoms easily attach to form chemical compounds.

Radiation Protection Activities in India

(*Continued from page* 7)

variety of instruments and devices used in the industrial applications of radioisotopes, such as radiography cameras, density guages, soil moisture guages, etc. have also been designed and developed.

The success of a countrywide radiation protection programme would depend ultimately on the ready availability of a large number of radiation monitoring instruments. This need is fulfilled by the Electronics Corporation of India, Ltd., Hyderabad, which mass-produces instruments developed at the Bhabha Atomic Research Centre, Trombay. ●

Contamination Monitor. This instrument consists of a scaler, a rate meter, an aural indicator and a regulated variable power supply.

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Seminar at Trombay

Preserving Food By Irradiation

A TWO-DAY Seminar on Food Irradiation, jointly sponsored by the Bhabha Atomic Research Centre, the International Atomic Energy Agency and the Food and Agriculture Organization, was held January 13-14 at the Food Irradiation and Processing Laboratory of the Bhabha Atomic Research Centre, Trombay.

The Seminar brought together specialists and researchers in food sciences and technology, representatives from the industry, public health and administration and Ministries of the Government of India for exchange of information and discussions with IAEA experts and Trombay scientists. The IAEA participants were: Dr. Walter Urbain, Professor of Food Science, Michigan State University, USA; Dr. Harry E. Goresline, Food Irradiation Specialist, IAEA, and Dr. Maurice de Proost, Head of the Food Preservation Section, Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, Vienna.

The Seminar was inaugurated by Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre.

Welcoming the participants, Shri Sethna said the Centre had all along been actively applying itself to various peaceful applications offered by atomic energy. In particular, he said, it had active on-going programmes in basic biological disciplines as well as in crop improvement and food preservation. Recognising the immense potentialities of radiation preservation of food, the Centre had been giving top priority to programmes on conservation of perishable foods. Recounting the status of food irradiation in advanced countries, Shri Sethna observed that the need for this new technology in developing countries was greater because of their problems of over-population, adverse climatic conditions and meagre storage and distribution facilities. At Trombay, he said, experimental studies had been in progress for some time and, during the last year or so, the facilities had been expanded for scaling up trials with promising processes to ascertain their technological merits and feasibility in practice.

Unfounded Fear

In this context Shri Sethna noted that a certain degree of misunderstanding on the safety as a whole of irradiation procedures for food preservation had been created by the recent decision of the U.S. Food and Drug Administration to defer clearance of radiation sterilized bacon and ham in that country. That this fear was unfounded, he said, was well-known to those concerned with the pursuit and implementation of the programmes. No process, not even the ones widely practiced today, he stressed, could be considered safe or satisfactory unless adopted under specified standard conditions.

At the Bhabha Atomic Research Centre, he said, emphasis had hitherto been on protective radiopasteurization rather than on absolute sterilization. The Centre was in the process of ascertaining the practicability of certain processes with other appropriate agencies of the Government, he added.

Tarapur Reactor Start-up Sources Produced in CIRUS

The first batch of irradiated antimony pencils for start-up of reactor No. I. of the Tarapur Atomic Power Station being loaded into a shipping container. These pencils were irradiated at the CIRUS reactor. (Please see pages 4-5.)

The Director also disclosed that, through the help of the United States Atomic Energy Commission, a portable 100,000 curie Caesium^{137} irradiator would be procured for furthering programmes on preservation of sea foods. This would be in addition to the two existing cobalt-60 irradiators of 100,000 and 28,000 curies gifted to the Centre by the Government of Canada. He added that there was a proposal to install the coming irradiator at one of the coastal regions where Government already had a certain amount of organized facilities for catch, handling and storage of sea foods prior to distribution. The advantage in radiopasteurization of sea food like shrimp, Bombay duck, and pomfrets immediately after catch, he said, lay in the fact that much lower doses of radiation would suffice for appreciable extension of shelf-life than would otherwise be the case. The Central Institute of Fisheries Technology at Veraval and Bombay, he said, was associated with Trombay in these studies.

(*Continued on page* 2)

Food Irradiation Seminar at Trombay

(Continued from page 1)

Another project at hand is grain disinfestation with gamma rays. This is being compared with fumigation practices in experimental storage bins at Trombay. In this work, the Directorate of Storage and Inspection of the Department of Food, he said, was giving BARC an active helping hand. It is expected that these efforts would lead, in the very near future, to practical scale grain disinfestation with cobalt-60 gamma rays.

Participants examining irradiated products at the Food Irradiation and Processing Laboratory, BARC.

Emphasis on Four Aspects

The Director also mentioned that a preliminary survey for commercialization of the irradiation process for preservation of potatoes and onions had been completed. In all these studies, the Food Research Laboratories of the Ministry of Defence had aided the Centre in quality and acceptance evaluation.

The Seminar was opened with general observations on work at the Bhabha Atomic Research Centre by Dr. A. Sreenivasan, Head of the Biochemistry and Food Technology Division of the Centre. Dr. Sreenivasan said, in the selection of projects for development along practical lines, emphasis had been placed on four aspects, namely: grain disinfestation, sprout inhibition in potatoes and onions, shelf-life extension in sea food and other flesh foods and eggs, and delayed ripening in mangoes and bananas.

In these efforts, Dr. Sreenivasan said, the researchers had naturally been guided by international developments and the status of the programmes elsewhere, at the same time bearing in mind the fact that development of specific programmes would obviously be conditioned by geographical factors like availability of raw materials, their seasonal distribution and other local problems and practices. In this manner, he said, the adoption of any special provisions on food irradiation would be facilitated by the already existing clearances in other countries.

A E C Secretary

Shri T. N. Seshan, IAS, Deputy Secretary in the Department of Atomic Energy has been appointed Secretary of the Atomic Energy Commission. He took over from Shri Y. S. Das on December 16, 1968.

In addition to the programmes already in hand, Dr. Sreenivasan added, the Bhabha Centre would be pioneering new processes for radiation preservation of foods, in the context of prevailing conditions and needs, and against the data and experience that were already available.

He also observed that an important aspect in the development of the BARC programme was that bridges were being established with other concerned ministries of the Government. Because of the sophisticated technology and high capital equipment involved in radiation processing on a large scale, he observed that in order to be economical, the application of irradiation procedures would have to rest with the Government for some time. In this way, he felt, many of the hazards to producers and consumers alike, which are likely to arise by the handling of food irradiation processes by individual manufacturers, would be obviated.

Dr. Sreenivasan disclosed that collaborative efforts with the Ministry of Food and Agriculture were proceeding satisfactorily. The Ministry of Defence was also showing considerable interest in the BARC programme and was helping in the large scale evaluation of processed products for acceptability and other quality attributes. BARC was also engaged in active researches pertaining to wholesomeness testing, with its several aspects, namely sensory evaluation, nutritive value, microbiological safety and freedom from any toxic effects, he added. ●

Ever Creating New Frontiers

Excerpts from an address by the Director of the Bhabha Atomic Research Centre, Shri H. N. Sethna, to the participants of a Short-term course in High Vacuum Technology at the Indian Institute of Technology, Madras, on December 22, 1968.

THE development of modern science and technology has placed an ever-increasing demand on new and modern materials to stand stringent conditions. In the search to meet these demands one has to take into account the limitations imposed by nature. The success in developing a new material will depend entirely upon our capacity to explore nature in a scientific manner, and to acquire the maximum useful knowledge from these investigations. This has to be followed by our willingness to make compromises with nature in the spirit of a good engineer. Progress in this field depends on the cooperation between the scientist who explores nature and the engineer who uses the results to produce materials.

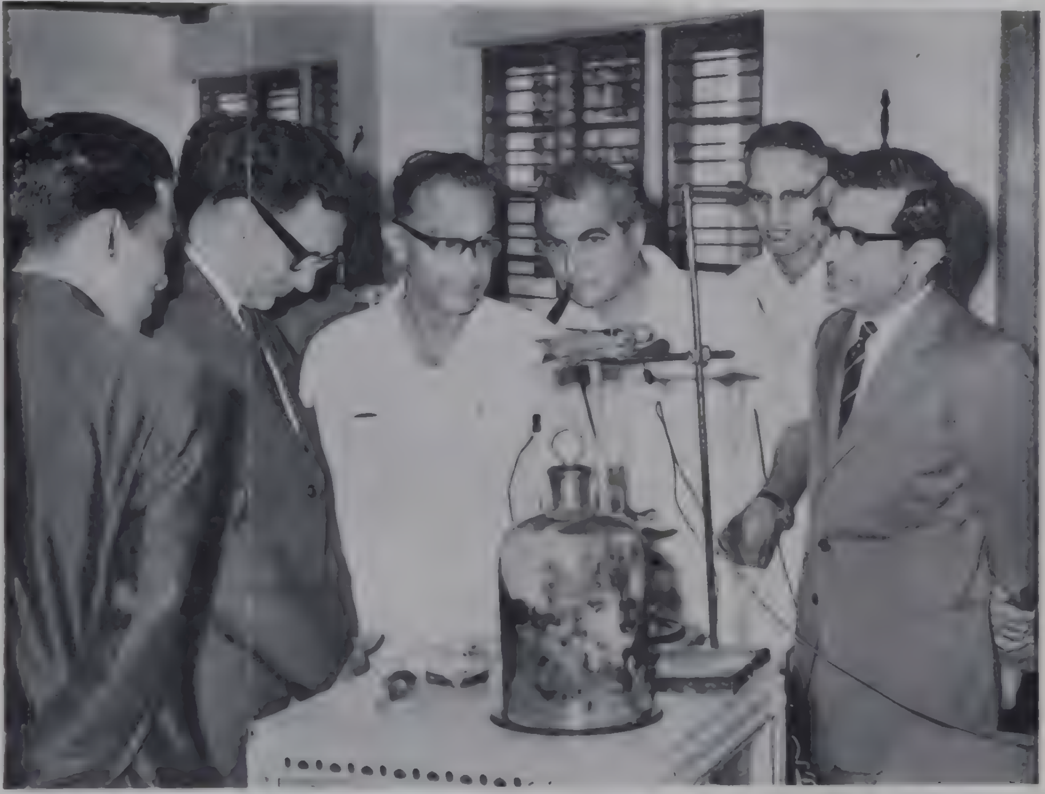
The development of materials dates back to pre-historic days. The discoveries were entirely based on empirical observations, an element of inspiration, and trial and error. With the development of science, the situation has changed. In the present century, science has begun to generate entirely new frontiers for advance in this field. The development of the science of mechanics has made it possible to introduce static and dynamic testing in a systematic manner. This in turn has led to the science of the strength of materials. The refined development of the theory of elasticity is one aspect whilst the laws of plastic flow under stress of relaxation effects and of creep, are others.

Another Important Tool

The study of crystallography was initially developed as a branch of minerology and has had a profound influence on the study of grain structure of materials. Advances in this field of study are mainly due to the development of the optical microscope in the last century and to the electron microscope, X-ray neutron and electron diffraction apparatus during the present century.

Considerable advances in the science of chemistry in the last century have furnished another important tool in the field of materials technology by making it possible to understand and control compositions.

In the early 20th century, the Chemist played a very important role in the development of materials and helped the engineer considerably in his work. In fact, he became a rather dominant figure in many fields such as metallurgy and ceramics. His work made it possible to produce and refine in a controlled way many substances such as silicon carbide, metallic aluminium, titanium and uranium which are not found in the free state in nature. The Chemist has also succeeded in developing new materials such as synthetic polymers which are the results of highly sophisticated principles of theoretical structural chemistry.


From left: Dr. A. Ramachandran, Director, IIT Madras, Shri H. N. Sethna, Shri N. S. Siva, Officer on Special Duty, Madras Atomic Power Project, Dr. A. R. Gopal-Ayengar, Director of the Bio-Medical Group, BARC, Shri C. V. Sethuraman, Registrar, IIT, and Shri C. Ambasankaran, Head, Technical Physics Division, BARC, with a Trombay-developed vacuum kit displayed at IIT.

The preparation of the synthetic diamond and other compounds has been the result of his understanding the principles of thermodynamics and the problems of relative stability of different phases of a given substance or combination of substances.

The development of atomic physics now provides one of the most significant factors in this field. Through the understanding of the electronic structure of the perfect crystal, the Physicist has evolved the band theory of solids and its refinements. The Physicist has also been concerned with the imperfections which the crystal may sustain in its interior. The foundations of these subjects were laid in 1940 and, by 1950, the concept of free electrons and holes, imperfection centres, vancies and interstitial atoms and dislocations had become common. The invention of the transistor in 1948 on the basis of theoretical concepts is one of the results of the application of this investigation. It signifies the coming of age in a practical sense of the physics of solids. This development demonstrated that many innovations could be expected

(Continued on page 7)

CIRUS CONTRIBUTES

Centre, Trombay has been entrusted with the task of preparing start-up sources for the reactors at the Tarapur Atomic Power Station.

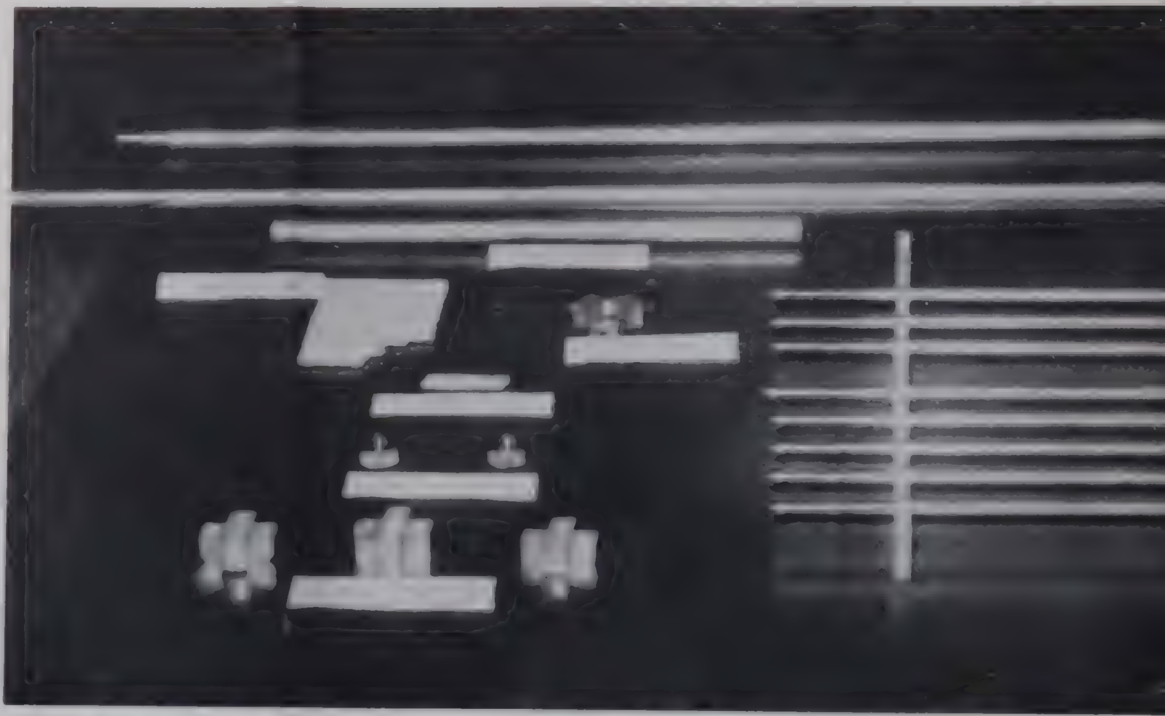
The enriched uranium fuelled, boiling light water reactors at the Station need intense antimony-beryllium (γ, n) sources to provide sufficient neutrons for safe and efficient start-up of the reactors. At the request of International General Electric Company, the Isotope Division of BARC contracted to supply 14,000 curies of antimony^{124} γ sources in the form of 32 stainless steel clad antimony pencils (8.18 mm dia. and 54 cm length).

In meeting IGE's demands, the versatility of the Centre's set-up was very much reflected. The Reactor Operations Division designed and engineered the nuclear aspects of the assembly for irradiating the pencils in the reactor CIRUS, after carrying out trial irradiations to meet rigid IGE specifications. The Atomic Fuels Division fabricated the components for this rig which was assembled and irradiated in CIRUS by the Reactor Operations Division.

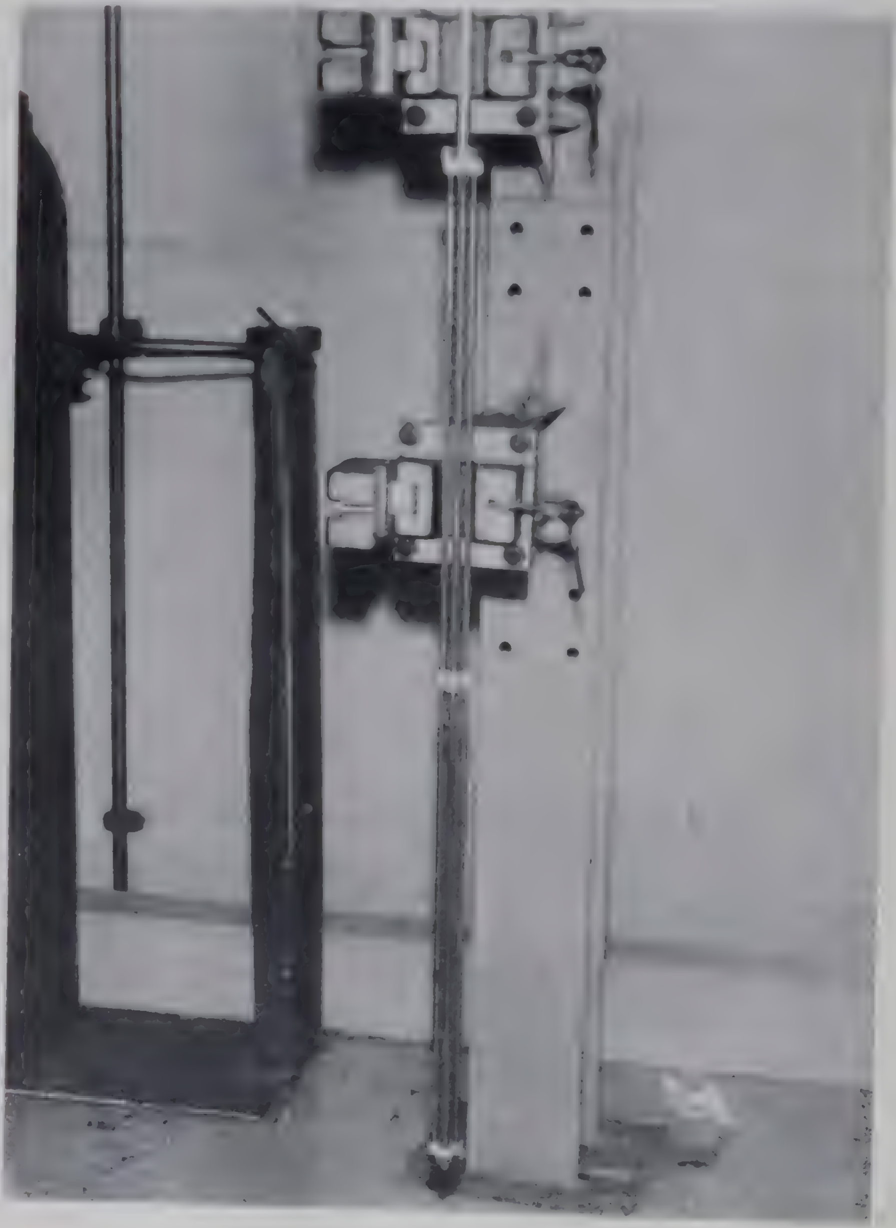
Final Checks

The first set of 16 pencils was irradiated between November 1967 and February 1968, but due to rescheduling of the Tarapur reactor start-up, it had to be stored in CIRUS itself. The sources however decayed during storage and had to be reirradiated. This was done during the period November 1968—January 1969. The first set of source assembly was removed from the reactor on January 17 this year and processed under water in the fuel rod handling bays.

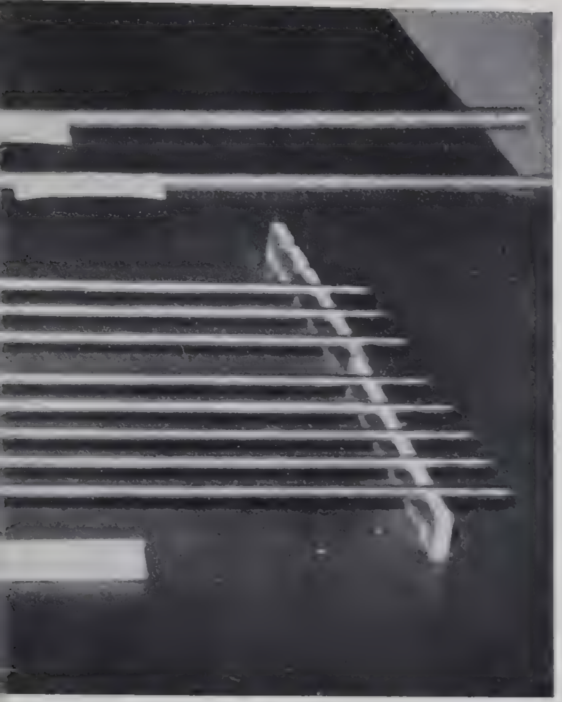
Special five tonne containers for the 16 pencils were designed and fabricated by the Central Workshops of BARC. The pencils are now with the Isotope Division for source strength measurements and final contamination checks before delivery at Tarapur.



Above. Fresh antimony pencils and components. *Below* The pencils in assembly.



REACTOR START - U



Above. Extraction of irradiated pencils under water in the fuel rod bays. *Below.* Container for shipping the pencils.

Messengers from Outer Space

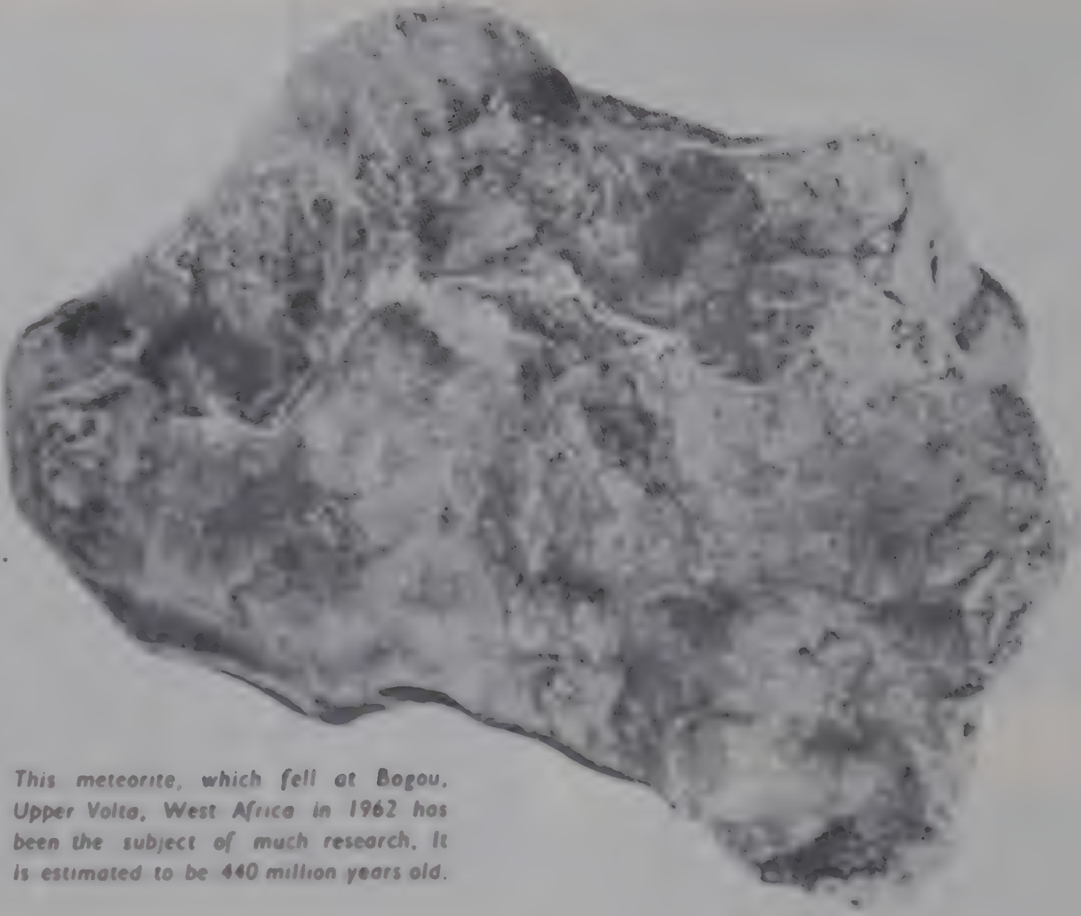
ALTHOUGH no evidence has yet been confirmed of living beings reaching the earth from space, it has been estimated that hundreds of tons of solid matter arrive every day in the form of meteorites or cosmic dust particles. Much is destroyed by heat in the atmosphere, but fragments recovered can give valuable information about what has been happening in the universe for billions of years.

Last August, in Vienna, a Symposium on meteorites organized by the International Atomic Energy Agency (IAEA) in cooperation with UNESCO, the Joint Commission on Applied Radioactivity, the International Astronomical Union, the International Union of Geological Sciences, the International Association of Geochemistry and Cosmochemistry and the Meteoritical Society, revealed some interesting information on the work being carried on in different parts of the world in this subject.

Curiousity and Fear

At the opening meeting, Professor B. Grinberg, Director of IAEA's Division of Research and Laboratories, spoke of the importance attached to the subject of meteorite research by the scientific community. The spectacular nature of the fall of some meteorites had, he said, aroused not only curiousity but often fear and superstition for many centuries. One of the meteorites which fell in the small Alsatian town of Ensisheim in 1492 was thought to have been taken by Emperor Maximilian I as a sign from the heavens to mount a crusade against the Turks. In modern times, scientific work on meteorites had been transformed by the discovery of new analytical techniques, particularly those based on measurement of radioactivity. These methods provided an example of the way in which the peaceful applications of nuclear techniques could advance human knowledge.

Professor Grinberg predicted that many reports presented would give results obtained with the new methods,



This meteorite, which fell at Bogou, Upper Volta, West Africa in 1962 has been the subject of much research. It is estimated to be 440 million years old.

Crystal size in the meteorite indicates that it was originally part of a much larger body and that cooling was very slow. Much of the surface was burned or melted after entering the atmosphere at about 125,000 miles an hour.

and his forecast was fully borne out. Some of the information was obtained from determinations of the products of decay of natural radioelements: helium-4 from uranium and thorium, argon-40 from potassium, and strontium-87 from rubidium. This information is directly relevant to considerations of the radiogenic age of meteorites — the time during which they have existed as parts of solid bodies. In the gaseous or liquid state, decay products are rapidly transported away from the site of their formation by convection or diffusion. The solidification of matter, however, sets the radiogenic clock to zero: decay products from this moment accumulate at the site of their origin at rates characteristic (and known) for each species, and their concentration is a measure of the time elapsed since solidification took place.

From different measurements and calculations reported at the meeting, it now seems firmly established that the solid matter in meteorites is up to 4.7 billion years old. This value corresponds well with that determined for the age of the earth.

"Radiation Age"

A different kind of information was provided by the measurement of products of cosmic radiation, including non-radioactive materials such as argon isotopes 36 and 38 and radioactive argon-39 and chlorine-36. Their measurement provides a clue to the "radiation age" of meteorites, the time during which meteorites have existed as separate small bodies in space, no longer shielded from cosmic radiation by the large parent bodies in which—according to most theories—they are believed to have been buried and from which they were released by their breakup, probably due to collision. Such radiation ages are typically several hundred million years for iron meteorites and from less than one upto about sixty million years for most stony meteorites. Different types of meteorites also fall into characteristic radiation age groups, which indicates that they were produced in different cosmic events and from different parent bodies.

One question discussed was whether meteorites originally came from asteroids, comets or from the moon. Lunar origin is now considered rather improbable, not only because an event leading to the ejection of a meteorite from the moon would have to be energetic enough to provide it with at least the lunar escape velocity of 2.4 km/sec, which would lead to shock structures not in fact observed in most meteorites, but also because recent measurements of lunar surface materials have shown its composition to be different from that of meteorites.

Some other facts interesting to the layman are that the cooling rate of a body in space 100 kilometers in diameter would be 1—10°C in a million years, and that erosion caused while travelling through space would be 0—1.1 cm in a million years. It is also considered that there has not been much change in cosmic rays during the last 10 million years.

Considerable efforts are being made to obtain meteorites as quickly as possible after they have fallen in order to gather the greatest amount of information about their radioactive contents. A meteorite which fell in France in 1966 was made available to laboratories within a few weeks, and eight papers at the symposium dealt with aspects of its analysis. Efforts are also being made to establish the trajectories through which the meteorites fall. So far only one has been recorded successfully on photographs and subsequently recovered, although there have been a number of photographs of fireballs.

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'The Challenge of High Temperature'

(Continued from page 3)

in the future by the use of knowledge gained by the physicist from the extensions of atomic physics. The rapid development of solid state electronics indicated the enormous magnitude of new frontiers that could be generated.

Inspite of the success in dealing with perfect or almost perfect crystals, there is a critical need for the development of new techniques and principles which will make it possible to have more direct knowledge of the surface properties of solids and of the effects of relatively dense clusters of imperfection in the interior.

The challenge of high temperature which has inspired the metallurgist to some of his more notable developments has in recent years led to the search for a new class of materials required by propulsion engineering, high speed vehicles and nuclear engineering.

The limits set to physical and chemical behaviour of metals are extended in many metallic derivatives which provide, either as oxide or as other binary compounds, the starting materials for ceramics. Ceramic materials, because of their high temperature behaviour both in regard to oxidation temperature and strength, play an important role in the range of engineering requirement which are at present limited by the properties of available metals. The problem is therefore to develop a suitable ceramic material which will be comparable to metals in resistance to thermal shock and which will surpass them in hot strength and creep resistance. These are requirements for gas turbine components and, to some degree, for fabrication of supersonic vehicles whilst, at the other extreme, we have materials which have a very high thermal shock resistance combined with resistance to chemical erosion for use in rocket nozzles.

Tremendous Gains

To this requirement, another dimension has been added in the field of nuclear engineering where the need for resistance to radiation damage is an absolute necessity. We have therefore under pressure of modern technological development to intensify our search for this class of materials which have been neglected in the past. It seems quite possible that in the very near future we will be able to discover materials which would give us an acceptable combination of high temperature strength and thermal fatigue

(Continued on page 8)

‘Interplay of Disciplines Essential’

(Continued from page 7)

resistance, thereby enabling us to extend the upper limit of engineering temperatures.

It is therefore apparent that there will be tremendous gains if more detailed investigations of materials are carried along the now familiar lines, and by exploring more thoroughly the physical and chemical properties of known compounds. The emphasis of such studies must be on greater purity and greater refinement of physical form and more detailed quantitative observations. The continuing success of this approach is demonstrated by the development during recent years of many new and useful metals, alloys, semi-conductors, ferro-electrics, ferromagnetics, superconductors and phosphors.

No Limit

Whenever successful advances in the study of one material takes place, there has been widespread effect on others. The processes of zone refining, developed to a practical state to purify semiconductor materials, has now become common in purifying many materials which can have a high economic value in the refined state. Also, as the quantity of materials available for study increases and they become the subject of more detailed examination by the new as well as old methods, new properties may be discovered. The discovery that bursts of induced emission may be produced in ruby when properly excited provides a typical example. The field of lasers is developing very fast. Similarly, the observation that appropriately prepared specimens of tinniobium alloy are superconducting in magnetic fields in the range of 100,000 gauss is another. There seems to be no limit to inventions which may be expected by continuing these investigations.

Success in the development of new materials will, in the future, depend to a large extent on the development of new and sophisticated techniques for process development. Production of clean ultra-high vacuum by novel methods of pumping, production of very high temperatures using a concentrated beam of electrons or lasers or the plasma torch, production of low temperatures using liquid helium or other cryogenic systems, production of very high pressures using fluid extrusion devices are but a few of these techniques. The Bhabha Centre has, in a small way, undertaken the development of some of these.

In concluding I may say that the development of materials will continue to be a highly co-operative affair in the future, involving the combined activity of several branches of science and technology. Each professional group has to appreciate the role of others and no single professional group will be entirely self-sufficient. The future development in this field will depend on the degree of interplay of various disciplines; they must learn to work together in an atmosphere of mutual respect based on a sincere appreciation of their mutual dependence.

Institutes of technology in this country have a very vital role to play in this respect. Realisation of these needs demands a proper reorientation of courses offered by them. There is a vital need for a close link between the pure sciences and the engineering faculties. In a particular institution, it may be difficult to cover all aspects of different technologies. It may therefore become necessary for these institutes to have specific types of technological research programmes for each of them. ●

Big Rise in Sale of Radioisotopes, Equipment

A SPECTACULAR rise was recorded in the sales of radioisotopes and related equipment and services by the Bhabha Atomic Research Centre, Trombay, during the calendar year 1968.

The sales, totalling Rs. 22 lakhs (including Rs. 2.59 lakhs in export) registered a 60% increase over the corresponding figures for 1967. A total of 17,700 consignments, including 10,945 for medical use, were supplied during 1968. Radioisotopes for internal administration in medicine, radiation sources of cobalt-60, iridium-192 sources for industrial radiography and gamma irradiators, constituted some major items, accounting for more than 50% of the sales.

Among the countries which bought Trombay-made radioisotopes during the year were Australia, Burma, Ceylon, Denmark, France, Kuwait, Korea, Rumania, Taiwan, Thailand and the United Arab Republic. This reflects the increasing confidence in Trombay products among overseas buyers to whom initial supplies were made by the Isotope Division during the past few years.

Among the equipment supplied by the Bhabha Centre, mention may be made of a Gamma Chamber-900 unit and a 5,000-curie cobalt-60 irradiator for which orders were received from the International Atomic Energy Agency, Vienna. Incidentally, Trombay-built radiography equipment for non-destructive testing are in regular use in Ceylon and Kuwait.

Besides sale of isotopes and equipment, the Isotope Division continued to assist industries and projects with radiotracer and radiographic services. In addition to radiotracer experiments for detecting leaks in underground water pipelines and process lines in the chemical industry, studies were commenced at the Vishakhapatnam Outer Harbour Project for tracing silt movement in the project area. Radiography service was offered to army and navy installations and atomic power projects, apart from various industries. ●

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TDC-12 Computer Commissioned At Bhabha Centre

THE first real time digital computer developed in the country, the TDC-12, was commissioned on January 21 at the Bhabha Atomic Research Centre, Trombay, by the Chairman of the Atomic Energy Commission, Dr. Vikram A. Sarabhai.

Designed and built by the Electronics Division of the Centre, this fast unit is capable of performing 2,50,000 additions and subtractions in one second and is intended for real time applications. Besides being useful in research in experiments like pulse height analysis, Bubble Chamber measurements etc, the unit has applications such as monitoring and control of nuclear reactors, power plants and complex industrial processes. The machine's real time capability is a unique feature by virtue of which it can communicate with external environment on a continuous basis and can be connected to a plant for continuous operation.

Reliability Tests

The decision to build the unit was taken during the middle of 1965. The design and assembly of the electronic system was completed by June 1968, and extensive accuracy and reliability tests were conducted to check the large speed electronic system involving tens of thousands of intricate parts. During trial operations, powerful diagnostic programmes were developed to trap machine malfunctions, and marginal check procedures were established to assure trouble-free operation.

In the development and successful completion of the project, the Computer Group of the Tata Institute of Fundamental Research gave very valuable assistance.

A COMPUTER'S WELCOME. The Chairman of the Atomic Energy Commission, Dr. Vikram Sarabhai, and the Director of the Bhabha Atomic Research Centre, Shri H. N. Sethna (centre) respond to the formal welcome by TDC–12 which says: "The Trombay Digital Computer TDC–12 takes this opportunity to welcome the Chairman, the Director, and the guests on the occasion of its formal commissioning, and thanks for the privilege."

The Electronics Corporation of India Ltd., a public sector undertaking of the Department will now take up the production of the machine. The first commercial unit is expected to be ready by 1970. Thereafter, around 10 machines a year would be produced by the Corporation for sale. It is estimated the cost of the computer would be competitive with imported ones and that there will be a good market for such units both in India and abroad.

Commissioning the unit, Dr. Sarabhai said that on-line computers had wide applications in different fields besides atomic energy. Citing the

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Electronics Industry Must Compete Abroad

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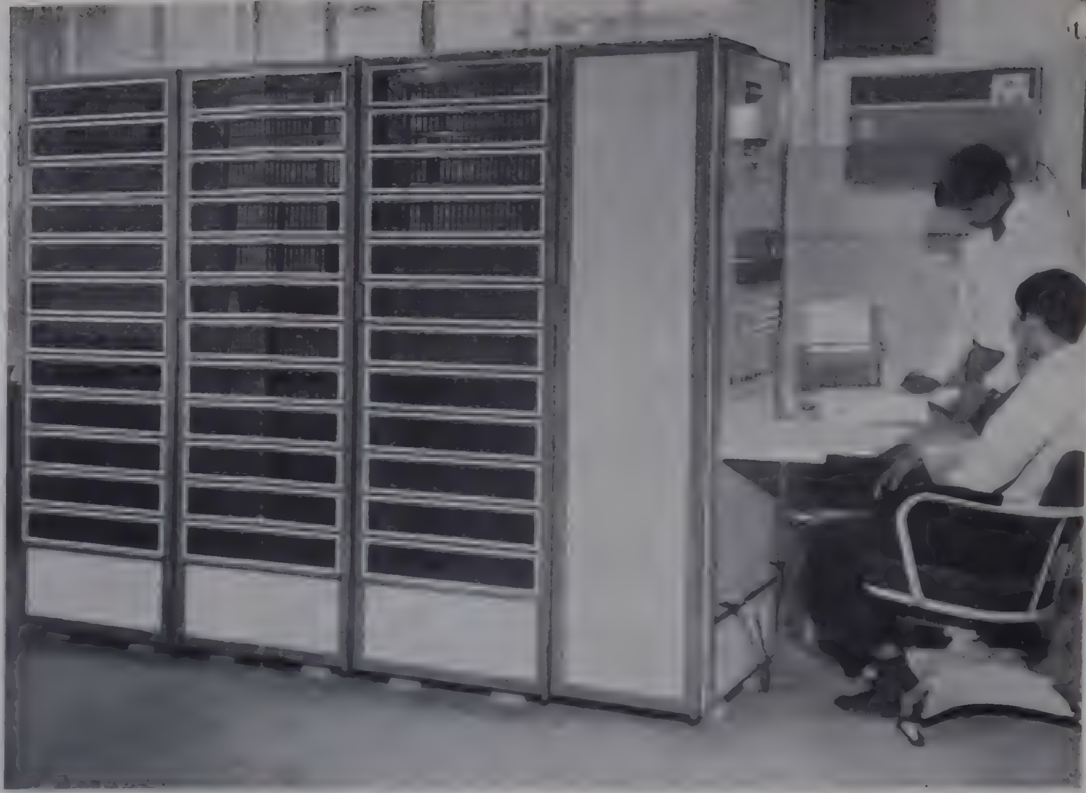

Another view of TDC-12 at Trombay

example of air defence, he said an on-line computer, in conjunction with a radar, could keep track continuously of hostile aircraft and thereby provide precise data for interception.

The electronics industry in India, he said, should not confine its aims and objectives to the attainment of self-sufficiency, but should think of competing in the world market with its products. India fortunately, he said was well placed in this regard as both hard and software, technical competence and skill available in it were as good as in any other country. With relatively low labour costs, it should be possible for India to compete with more advanced countries in this field.

Growth of Trombay Programme

Speaking before Dr. Sarabhai, Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre said since 1952, when the Electronics Unit was started, the Centre had been able to design and build various type of nuclear electronic instruments and associated equipment essential for the atomic energy programme. Tracing the growth of the Trombay electronics production programme, he said it had reached a stage when, along with the Electronics Corporation of India, it was providing part of the requirements in respect of power reactor instrumentation for the Tarapur Atomic Power Project and the Rajasthan Atomic Power Project.

On the basis of a careful assessment of the country's requirements in the field of computers, Shri Sethna said it was decided to undertake the development of medium sized digital computers and special purpose analogue computers at BARC.

Whereas, small size computers were already being manufactured under licence in the country, he said the development of large, high speed computers such as the CDS-3600 and the more recent CDC-3600 involved not only the most sophisticated electronics, but also the most advanced form of mathematical logic.

Highly Competitive Field

The field of large high speed computers, he said, was highly competitive and only two or three countries in the world were at present capable of producing such computers. Therefore, until the indigenous computer industry was established firmly and came of age, India would have to depend on the import of large high speed computers or would have to build them in India with foreign collaboration.

Earlier, Shri A. S. Rao, Director of the Electronics Group at the Bhabha Centre, said, when some ten years ago, the Centre started work in the field of computers, its objective was a modest one. It was then interested in designing and building a large analogue computer for use as a tool for solving complex mathematical problems encountered in the design of reactor control systems. That computer, with 60 operational amplifiers, became operational by the end of 1959. Even though it was designed and built at a time when electronics was still in its teens in the country, that computer, he said, had given trouble-free service and was being used even today for solving various engineering problems.

The success of the venture inspired the scientists to move ahead and go into the problems connected with the building of larger and more sophisticated analogue and digital computers.

He said the normal pattern of going through successive stages of first developing a system and then adopting it for production is too time-consuming and might result in an obsolete machine by the time it reaches the market. This is particularly true of computers because of rapid technological progress in the field. Consequently, the development effort was increased considerably to ensure that the first model would in fact be the production prototype. Further, it was also decided to use indigenous components except in case of items which were not manufactured in the country. This indigenisation had been done, he said, without any sacrifice in performance or reliability. ●

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While intimating change of address, the code and number given on the wrapper should be mentioned.

Of Water Sources

INTEREST in water supplies and water sources on a worldwide basis makes methods of accurately tracing water movement of great importance. A nuclear technique to evaluate mixing proportions of water from different sources has been developed by J. K. Osmond, H. S. Rydell, and M. I. Kaufman of Florida State University's Department of Geology for use in hydrologic investigations. The technique measures disequilibrium patterns of naturally occurring uranium-238 and uranium-234. In closed water systems more than a million years old, the alpha activities of the two isotopes are in equilibrium. However, in open systems that are subject to weather and circulation of groundwater, isotope separation can occur, and U-234 can be formed from alpha and beta decay of U-238: Nuclear recoil-induced bonds can be broken; U-234 daughters can be displaced within the crystal structure; and U-234 can preferentially attain the +6 valence, resulting in increased mobility and preferential leaching of the lighter isotope.

Only Element

The activity ratio of U-234 to U-238 in rivers is usually greater than 1.0, and in oceans, the excess is 15 per cent. In waters where the uranium source is weathered rock, the ratio is less than 1.0. The method can be used to calculate the mixing volumes of several waters that contribute to another water, such as a spring and a river contributing to water in another spring.

Uranium, the three scientists say, is the only element that can be used for this purpose. Thorium has a greater range of activity ratios in water, but occurs only in low concentrations. Hydrogen, carbon, and radium have too short half-lives to be useful as indicators. The report appeared in the November 29 issue of *Science*. *(Nuclear News*, January 1969). ●

Tarapur Reactors Become 'Critical'

Nuclear energy will be making its debut as a source of electrical power from July this year when the Tarapur Atomic Power Station is expected to be commissioned.

Both the reactors at the station are now ready to go into operation. Reactor No. 1 became critical on February 1, while Reactor No. 2 reached the stage on February 27. Numerous tests are in progress. It is expected that power will begin to flow from the Station from May on an "as available, when available," basis, and full commercial operation would begin around the end of July, when the Station will be delivering 380 MW to the States of Maharashtra and Gujarat.

Interconnection facilities to enable the two States to draw power from the Station are almost ready. Operating instructions for the interlinking of the grids of Maharashtra and Gujarat through the switchyard at Tarapur are under preparation. The Electricity Boards of the States are making efforts for an early interconnection to facilitate the start up and commissioning of the Station and its integration with the grid. Tarapur, incidentally, will be the first large centrally administered station.

World's Largest Irradiation Plant

THE world's largest commercial irradiation plant is under construction at Hanover, New Jersey, USA, reports *Nuclear News*, a publication of the American Nuclear Society. The Radiation Machinery Corporation, which will run the plant, has purchased 3 million curies of cobalt-60 for the purpose. The unit's pool irradiator, which will ultimately be expanded to 5 million curies, will be used for the production of wood plastic parquet floor tiles.

Symposium on Cancer At Tata Memorial Centre

A FOUR-DAY Symposium on Cancer was organized by the Tata Memorial Centre, Bombay, during January 20-23rd, 1969.

Bringing together nearly 50 medical scientists from all over India, six visiting scientists from abroad, plus a number of observers, the Symposium sought to focus attention on different aspects of cancer research in the country to stimulate intensive study of it on a national basis.

Dr. Vikram A. Sarabhai, Chairman of the Atomic Energy Commission, and Chairman of the TMC Council, inaugurated the Symposium in the distinguished presence of Dr. P. B. Gajendragadkar, Vice Chancellor of the University of Bombay. Dr. Sarabhai underlined the widespread applications of atomic energy in cancer research and treatment, and said that symposiums like the one which he was inaugurating would help greatly in bringing about collaboration among scientists working on varied aspects of the problem.

Integrated Approach

Dr. Gajendragadkar dwelt on the ethical aspects of cancer research and said that high idealism coupled with a religious fervour must be the driving force in a true researcher in the field.

The Symposium included panel discussions and special lectures. The panel discussion on Thyroid Cancer, moderated by Dr. Borges, focussed attention on the disease as it affects humans, and the situation confronting the clinician. The lectures described recent trends in certain areas of research.

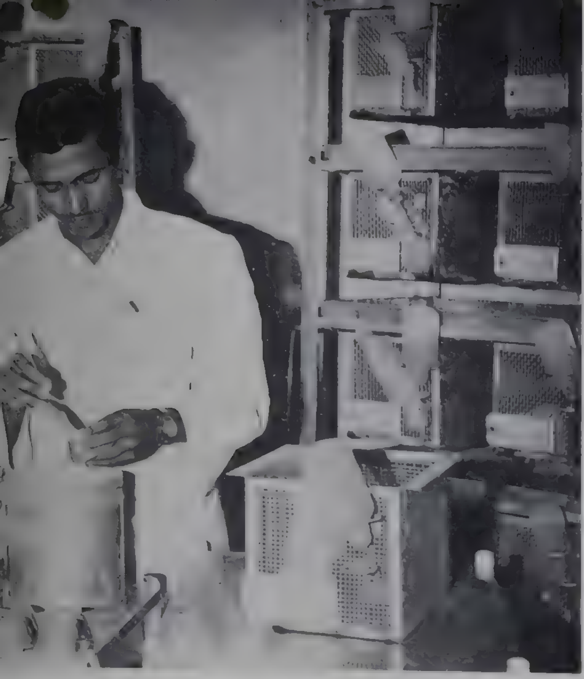
The integrated approach towards the disease was exemplified in the Symposium by the reports given in the six half-day sessions devoted to experimental research. They brought out the interaction of disciplines like epidemiology, biochemistry, biology, chemotherapy, radiobiology and biophysics. ●

Quality in wheat, for bread making is dependent, among other things, on the water holding capacity of gluten. This is shown being estimated in a Brabender unit

Long-term wholesomeness studies covering sev
nutritive value and safety for human consump

WITH population growth continuously outstripping agricultural production, food remains a major problem in large parts of the developing world. Besides the inevitable economic disturbances in the region, this imbalance is causing enormous damage in terms of human health. It has been estimated that over 50 per cent of the world's population suffers from hunger or malnutrition, or both. Lending urgency to this problem is the alarming prospect of feeding an additional 4.6 billion mouths over the

At left and below: Some stages in the pre-tr



ions of rats and mice being carried out to establish
iated foods.

An important aspect of any food processing is sensory evaluation of the product. Here, a taste panel assesses radiation-processed foods for quality.

Food Irradiation at Trombay

Review of a Seminar on Food Irradiation held at the Bhabha Atomic Research Centre on January 13 and 14, 1969.

sent 3.4 billion, just 41 years away.
s increase, according to U.N. ex-
s, will be mostly in the develop-
countries, some of which are al-
ly experiencing chronic food short-
.

art of the solution of course lies
ncreasing all-round food output
pled with an aggressive drive to
rd population growth.

n important complement to these
ts is conservation and preserva-
of food. This means making a
r portion of the produce avail-

able for human consumption or, in other words, preventing a large portion of the food from becoming unfit for people.

For almost two decades, research has been going on in several countries in the use of nuclear energy for food preservation to supplement, and in some cases, to replace traditional methods. Presently, some 76 countries, constituting 80 per cent of the world's population are already engaged in research, or are planning to initiate

(Continued on page 6)

cedures for radioprocessing of shrimps.

Effects of irradiation on respiration in fruit, vegetable tissues being determined in a polarograph

(*Continued from page 5*)

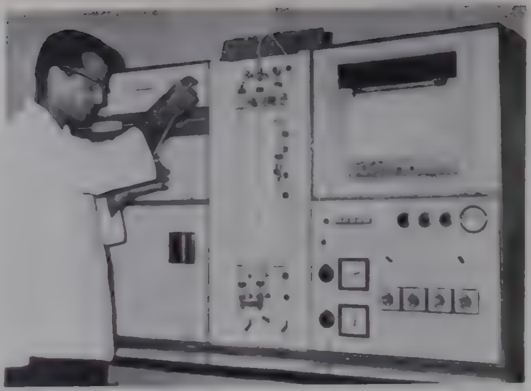
food preservation programmes. In a few, notably the USSR, Canada and Israel, some items of irradiated food have already been cleared for human consumption.

In India, work in this area has been going on for some time at the Food Irradiation and Processing Laboratory (FIPLY) of the Bhabha Atomic Research Centre, Trombay. Here, emphasis has been placed mainly on four aspects of immediate relevance to the country. These are: grain disinfestation, sprout inhibition in potatoes and onions, extension of shelf-life of sea foods and flesh foods, and delaying of maturity in mangoes and bananas.

The progress of research at the Centre was brought out in a number of status reports that were presented at the Joint BARC/IAEA/FAO Seminar on Food Irradiation held at FIPLY on January 13 and 14, (see *Nuclear India*, January 1969).

Apart from the reports of BARC scientists, informative lectures on the fundamentals of food irradiation were delivered by three international experts: Dr. Harry E. Goresline, Food Irradiation Specialist, IAEA, Dr. Maurice de Proost, Head, Food Preservation Section, Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, Vienna, and Dr. Walter Urbain, Professor of Food Science, Michigan State University, USA. These lectures provided a useful background to the proceedings, of particular benefit to several of the participants not actively engaged in food irradiation.

SPEAKING on planning for a research programme in food irradiation, Dr. Goresline enumerated the various factors that have to be considered to ensure that the process is feasible and economical. In the actual planning of the experiments, he stressed that so far as is possible, the number of variables to be studied should be kept to a minimum in the interest of economy of time, material and effort. He held that uncontrolled fluctuations in pre-treatments, actual process of irradiation or post-irradiation storage conditions could cause as much variability in the results as any of the experimental factors being investigated.



An amino acid analyser being used for accurate assessment of protein composition of various radiation-processed foods.

Dr. Goresline also brought out that the acceptable minimum radiation dose for any product has to be established on the basis of the microbiological, entomological and enzymological objective of the treatment in stabilising the product.

Describing food irradiation as a process, Dr. W. M. Urbain said that generally there is a minimum dose requirement, and the average above the minimum is usually controlled by legal requirements, practical considerations and economics.

SPEAKING on the economics of food irradiation, he said that since there is no commercial radiation processing experience in the food industry, estimation of costs is particularly difficult. He held that many of the factors involved in the costing of any conventional food process also applies to food irradiation. It is important to bear in mind, he said, that since much of the cost of irradiation is of a fixed nature and is incurred whether the facility is used or not, it is necessary to operate the unit as fully as possible for economy. Ordinarily, a single shift of eight hours provides 2,000 hours of operation per year and a three shift operation with about 6,000 hours per year is usually the maximum one can expect to obtain.

Basic biochemical studies on growth regulators being carried out for a better understanding of the mechanism underlying sprout-inhibition in irradiated potatoes.

The technological aspects of food irradiation were briefly described by Dr. M. de Proost with emphasis on the choice of suitable sources, dosimetry and safety systems. According to him, though initial research work can be done in small units of 1-3 litres capacity, when interest grows to the stage of industrial application, the work must be carried out in large units to obtain information on a scale that would have validity when extrapolated to commercial production. Pilot plants are necessary for working out problems of implementation, mechanical handling on large scale, continuity of operation and likely economics of the process.

Dr. de Proost also reviewed the food irradiation programmes of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture, and summarised the status of present research on disinfestation, pasteurisation and sterilization of foods through ionising radiations, as well as aspects of legislation and clearance of irradiated food.

SHRI D. R. Bongirwar spoke on design and problems of dosimetry in connection with the two pilot scale Co^{60} irradiators installed in the Food Irradiation and Processing Laboratory at Trombay. He said that one of the main considerations in the design of the package irradiator had been the need to obtain variable throughputs and dose rates to allow flexibility of operation for multipurpose usage.

The package irradiator (100,000 curies Co^{60}), consisting of large and small source racks, he said, was being used for experimental and developmental work for gamma irradiation of fruits, vegetables, sea-foods, flesh isation of medical supplies.

The through-flow irradiator (28,000 curies Co^{60}) is being used to test various irradiation conditions and technological problems pecular to application of radiation for disinfestation of grains in India. Shri Bongirwar disclosed that plans had been completed for comparative studies of post-disinfestation behaviour during storage of irradiated and fumigated grains in experimental silos of two tonne capacity, under fabrication.

Recounting the problem encountered in the dosimetry of the package irradiator, he said that the high overdose ratios of about 1.8 and 2.6 respectively for the large and small sources obtained initially after installation, had been reduced to 1.25 and 1.5 respectively by effecting several modifications in the design of the source, reducing the area of the product-box and increasing the number of passes for the product-box around the source racks.

SHRI S. D. Dharkar spoke on his work on the delaying of ripening in tropical fruits, especially mango and banana, by the use of gamma rays. Describing his studies, Shri Dharkar reported that a combination of skin-coating and irradiation extended the shelf-life of mangoes upto 16 days. This would be of considerable help in transporting the fruit within the country. For despatch to distant countries, he said the fruits would in addition require storage in refrigerated holds.

The extension in storage life of meat products exposed to different doses of ionising radiation being correlated with some biochemical parameters such as enzyme activities measured in a Beckmann spectrophotometer.

Selective control of microorganisms and their role in stabilising radiation processed foods being studied in the microbiology laboratory.

He also reported on the differences observed when mangoes were kept covered by either paper cuttings or dry paddy straw. Irradiated mangoes covered in this way showed twice the storage life (90 days) of the uncovered irradiated ones (40 days).

One of the main objectives of irradiation is protection of the produce during transit, and in this context, Shri Dharkar described studies on transportation of irradiated mangoes over long distances. It was observed by him that the combination process of skin coating and irradiation was best.

Shri Dharkar reported observing a similar delay in ripening of four Indian varieties of bananas by exposure to low-dose irradiation.

ANOTHER area of emphasis at BARC is inhibition of sprouting in potatoes and onions. Shri Dharkar said that low-dose irradiation can be used to considerable advantage in preventing the losses due to sprouting, while evaporative losses can be minimised by skin-coating.

In a typical study, onions were exposed to irradiation in the range 6-10 Krads, and subsequently stored at ambient (26°C — 32°C) or subroom (10°C) temperatures. Almost 100 per cent of the control bulbs stored in cold and ambient temperatures sprouted within 2½ months, and after six months, were completely spoiled and unsaleable, whereas the irradiated ones stored at both temperatures were found to be still in marketable condition.

Shri K. S. Karnik and P. N. Joglekar of the Department of Atomic Energy, Bombay, read a paper on economics of potato and onion preservation by use of irradiation. They held that even very preliminary investigations had established the economic viability of the commercialisation of the irradiation process.

In India, they said, only 7 tonnes out of every 10 tonnes of potatoes and onions grown are actually available for consumption, 3 tonnes being lost due to sprouting, dehydration, spoilage, rot etc.

DR. U. S. Kumta reported on the status of the programme relating to preservation of sea foods by radio-pasteurization. Programmes in this area at BARC, Dr. Kumta stated, had been undertaken with two objectives: (i) to develop radiation pasteurization procedures for tropical sea-foods, especially those which have defied other methods of preservation, and (ii) to use appropriate combination of conventional preservation techniques with irradiation so as to minimise limitations of either method, improve product quality and extend shelf-life.

In the case of Bombay duck, he said the storage life of fillets at 10-12°C could be extended to 21 days by 0.5 Mrad in contrast to rapid deterioration of unirradiated fish within 3 days. The radiation pasteurization process he maintained was of considerable technological significance for Bombay duck since hitherto this fish has not been readily amenable to canning or freezing.

Dr. Kumta also said that semi-dried shrimps and Bombay duck with 40 per cent moisture which spoil within seven days, could be stabilised for room temperature storage for about 3 weeks by irradiating the products with 0.25 and 0.5 Mrad respectively.

Dr. Kumta stated that promising results so far obtained were being scaled up with a view to testing the merits of the processes in commercial practice and these studies were being carried out with active collaboration

(Continued on next page)

Trombay Seminar on Food Preservation

(Continued from previous page)

of the Central Institute of Fisheries Technology, Veraval and Bombay sub-stations.

Dr. P. L. Sawant reported on the preliminary findings on radiation pasteurisation of lamb meat, a process which appears promising. Lamb meat, packed in polythene bags and subjected to gamma irradiation in the dose range of 0.25 to 0.90 Mrad at melting ice temperature, gave extension of storage life upto a maximum of 90 days when stored at 0°C. While no radiation odour was noticeable in samples irradiated upto 0.25 Mrad, it was found tolerable in those irradiated at 0.5 Mrad, and was quite pronounced in samples given 0.9 Mrad. The radiation odour was, however, found to be transient and disappeared during subsequent storage of samples at 0°C or 10-12°C; samples irradiated at 0.9 Mrad had normal odour within three weeks post-irradiation storage at 0°C.

IN a paper on grain disinfestation with gamma rays jointly prepared by G. W. Rahalkar and Anne J. Lewis, it was stated that there was enough data available to demonstrate that radio-sensitivity, measured either as sterility or lethality, was dependent upon the stage of insect development at irradiation.

Describing their studies, Shri Rahalkar and Miss Lewis said four radiation dose levels, 5, 10, 15 and 20 Krads were selected, and the response of various developmental stages of insects as regards inhibition of development or induction of sterility, was measured. Adult emergence was the main parameter selected for the assessment of radiosensitivity and, whenever adult emergence was observed, their reproductive potential was evaluated on the basis of total progeny produced.

Based on the experience gained, they said that studies had been planned to carry out large scale disinfestation of stored wheat by use of gamma rays from Co^{60} in a specially designed through-flow irradiator (28,000 curies) with a capacity to irradiate approx. 227 kg. per hour at 15,000 rads. The merits of the process would be compared with the currently practised fumigation process in experimental storage bins of 2-3 tonne capacity installed in the open.

Dr. (Smt.) U. K. Vakil presented data on the effects of ionising radiation on physico-chemical properties of starch and protein in wheat, and on the activities of anylase and protease, since these are important parameters in determining quality for bread-making. It was observed that irradiation results in increased initial reducing of sugars and diastatic activity and that amylose is more vulnerable to radiation damage than amylopectin. There is a significant decrease in glutenin and gliadin with concomitant increase in peptides and free amino acids as a result of irradiation.

She added that detailed investigations of various textural characteristics of dough indicate that irradiated wheat offers better resistance to stretching and uses more energy to extend the dough stability. These results suggest that elasticity of gluten and potential backing volume are improved in irradiated wheat.

IN another report, Dr. Vakil stressed the importance of knowledge on wholesomeness of irradiated foods to avoid recognised hazards to health, and detailed long and short-term feeding studies with rats and mice.

Wheat, irradiated at the insect disinfestation dose level of 20 Krad or at ten times this dose, was included at a high level (75 per cent) in otherwise nutritionally adequate diets and fed to the experimental animals for four generations, besides the parent generation. In addition to physiological studies on growth, reproduction, lactation and longevity, detailed studies on tissue function, hematology, histopathology and characteristics of intestinal microflora were carried out. No changes in any of these parameters were apparent in the animals fed the irradiated wheat, when compared to controls.

Similarly, no significant differences were observed between groups fed either unirradiated or irradiated (0.25 Mrad) shrimps as sole source of protein in diet in parent and first generation. Short-term studies (12-15 weeks) on rats fed on irradiated complete diets (20 and 200 Krad) also did not reveal any differences in growth, feed and protein efficiency ratios as compared to controls.

DR. A. S. Aiyar referred to reports on the cytotoxic effects of irradiated sugar solutions and other media on cell cultures and lower forms of life which had been interpreted by some to indicate a potential hazard in the use of irradiated foods. Detailing a series of experiments with irradiated sucrose solution, he pointed out that while it was found to impair oxidative phosphorylation and energy dependent biochemical processes at the cellular and sub-cellular levels *in vitro*, judged by various parameters, it was without any effect in the whole animal when fed orally. Similar *in vitro* toxicity was also observable with autoclaved sucrose solution. In a further study, it was observed that, when fed orally to rats, the components in irradiated sucrose solution responsible for *in vitro* toxicity are rapidly metabolised and excreted with no detectable retention in the tissues of the animal beyond 30 hours. These studies clearly point to the invalidity of extrapolations of findings with *in vitro* systems to whole animals endowed with efficient physiological and metabolic processes such as digestion, absorption, detoxification and excretion besides numerous hormonal and other regulatory control mechanisms. ●

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Centaure Rockets From Trombay

THE first India-made Centaure two-stage rocket was successfully flight tested at the Thumba Equatorial Rocket Launching Station (TERLS) on February 26.

Built at the Central Workshops of the Bhabha Atomic Research Centre, Trombay, under a collaborative agreement with Sud Aviation of France, the rocket, carrying a 30 kg-scientific payload, (including instrumentation to measure its own performance), reached an altitude of 150 km.

The payload functioned smoothly and the telemetry received signals throughout the flight. The radar tracked the rocket for 86 seconds to an altitude of 88 km, establishing a record for skin-tracking from Thumba.

New Dimension

With this successful launch, the country's space programme may be said to have acquired a new technological dimension as the fabrication of rockets is a complex process demanding special materials, precision-made components, and a high degree of technical skill. In the making of the first Centaure, a number of processes and techniques were used almost for the first time in the country.

Broadly, the Centaure comprises mainly of the motor casings of the two stages, a precision-built fin assembly for each stage, composite nozzles etc., in addition to a host of parts running into hundreds. There is, besides, an interstage separation device which causes the first stage of the rocket to fall off 6 seconds after launching. This is supplemented by sophisticated pyrotechnic and electrical circuitry. The second stage culminates in a long, graceful stainless steel nosecone housing the custom-built scientific payload for various experiments. Power is provided by two solid fuel blocks, one in each stage.

To maintain the trajectory, the rocket is made to spin at a considerable velocity by means of small spin rocket motors. The fully-assembled

(Continued on page 4)

Caught in Flight

An indigenous rocket soars past, powered by a new propellant developed at the SSTC, Thumba.

New Rocket Propellant at Thumba

A WHOLLY indigenous rocket propellant was flight tested at the Thumba Equatorial Rocket Launching Station (TERLS) on February 21. Developed by the Propellant Engineering Division of the Space Science and Technology Centre at Thumba, the composite type propellant was studied for its behaviour under dynamic conditions.

Launched at 65° elevation, the rocket reached a peak altitude of 4.2 km. with flight time 60 seconds. It was tracked throughout by ground based radar.

The rocket, launcher and other hardware were manufactured by TERLS.

A new type of propellant with natural rubber base has also been developed at TERLS. It was tested in three Rohini RH-75 rockets, on February 24. The peak altitude reached was 6.1 km. ●

IAEA to Start World-Wide Nuclear Information System in 1970

EVERY day, about 250 new articles, books or other items of information about atomic energy and its peaceful applications are published. A plan under which the International Atomic Energy Agency (IAEA) and its member countries will operate a computer-based system to keep track of this literature and make it available to individual scientists and engineers will be put into operation in 1970.

The IAEA Board of Governors has given its approval to the project, which involves creating an International Nuclear Information System (INIS). The object is to assist progress in nuclear energy by facilitating the dissemination of information, particularly in developing countries, and to save much duplication of effort.

As the pace of research and development increases, nuclear scientists and engineers are faced with the task of extracting particular items from a flood of new information. This appears in many different forms — as papers in scientific journals, as talks given to scientific conferences, as university theses, as patent applications on new inventions, as laboratory reports and as textbooks.

Member States of IAEA will be invited to report to INIS on all new items of information published in their countries. Their reports will be merged in Vienna to develop a catalogue of all the relevant literature. This catalogue, together with the full text of material not readily available through normal channels, will then be made available as a "data bank" from which relevant items can easily be extracted.

Detailed preparation has now been in progress for two years. The particular plan now adopted was first prepared by a team of 14 experts who worked for various periods in Vienna during the first half of last year. The recommendations of this team was reviewed, modified and endorsed in October 1968 by a Panel composed of 37 experts from 23 Member States and four international organizations.

Member States, or groups of them, will be asked to scan their literature and identify those articles of interest on nuclear science and technology. For each, they will prepare a complete bibliographic description, write a short summary, and assign a set of keywords, taken from a standard list, to identify the subject matter. By analysing these sets of keywords, computers can be used to extract from a voluminous file those items that deal with a particular narrow subject.

The bibliographic descriptions and the keywords will be recorded on magnetic computer-tape either by the country that prepares them or by the Agency in Vienna. The short summaries will be recorded on "microfiche." These are small pieces of photographic film about 10 x 15 centimetres, on which can be recorded 60-72 pages of text. They are cheap to transport and can be read with the aid of relatively inexpensive instruments.

The main product will be a magnetic-tape service. Participants receiving it will have the complete data bank and will be able to use it to carry out searches of the literature for the scientists and engineers that they serve. It will be possible to have a computer print out the title, the names of the authors, and other identifying particulars for each piece of literature. If a user needs more, he will be able to turn to his copy of the file of microfiches in order to obtain a short summary. And if he needs the full text, he can either go to his library or—if the item is not one regularly distributed—order a microfiche copy of the full text from the IAEA. ●

Summer School at Bangalore

Under the auspices of the Tata Institute of Fundamental Research, Bombay, a Summer School in Physics of Condensed Matter will be held at the Indian Institute of Science, Bangalore from June 9 to June 27, 1969. Lectures will be given by Prof. K. S. Singwi of Argonne National Laboratory, USA on "The Theory of Atomic Motions in Liquids" and by Prof. A. T. Stewart of Queen's University, Canada on "Positron Annihilation in Solids and Liquids."

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I, Jagannath Sharma, hereby declare that the particulars given above are true to the best of my knowledge and belief.

March 1, 1969.

(Sd.) JAGANNATH SHARMA

Aeronomy Symposium At Ahmedabad

NEARLY 70 foreign and 100 Indian scientists participated in the Third International Symposium on Equatorial Aeronomy held at Ahmedabad during February 3-8, 1969. Professor Sydney Chapman, the doyen of Aeronomy and Geomagnetism, inaugurated the symposium.

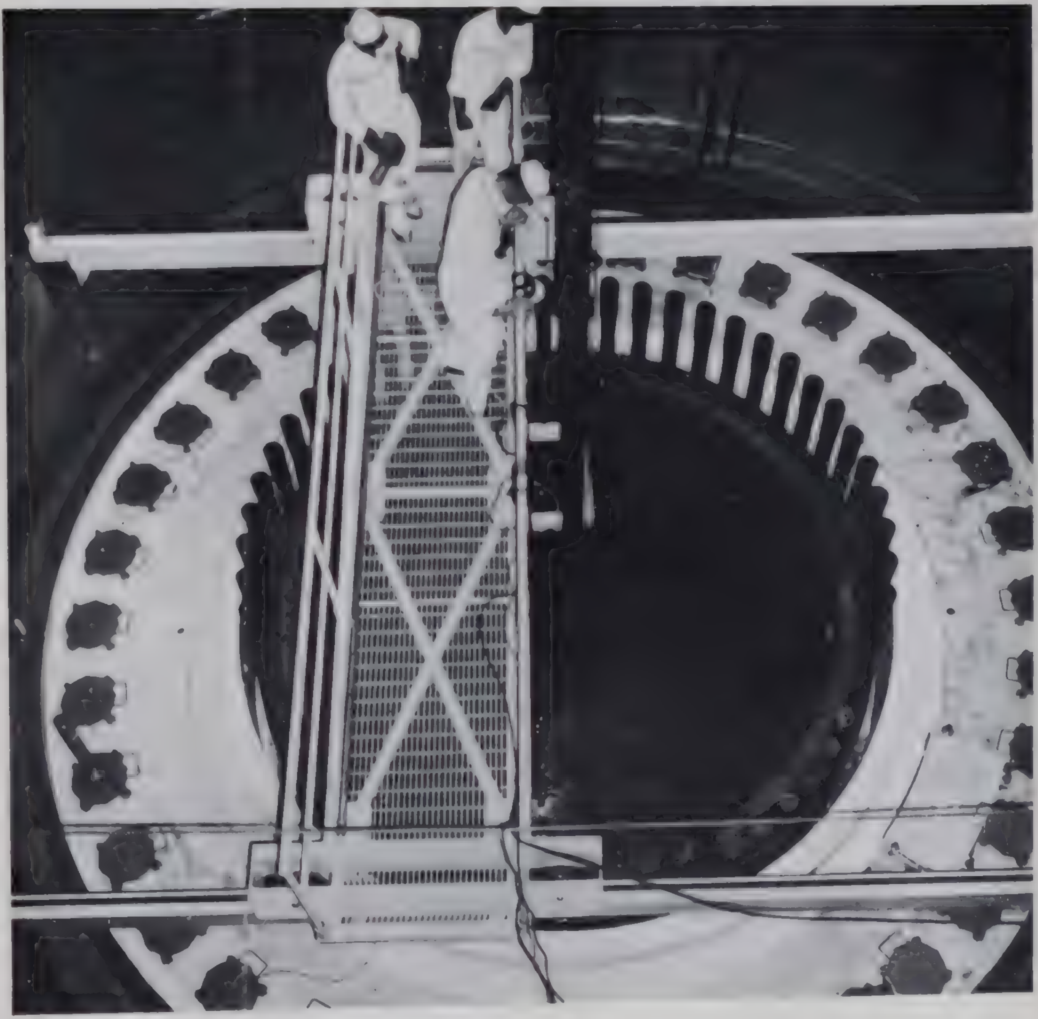
The first Symposium on Equatorial Aeronomy was held in Peru in 1962, and the second at Sao Paulo in Brazil in 1965.

In his opening remarks, Dr. Vikram A. Sarabhai, Chairman of the Atomic Energy Commission and Chairman of the Indian National Committee for Space Research, stated: "Aeronomy covers many areas of great interest to the pure scientists ... It is of particular significance to the economies of the countries which depend largely on agriculture ... The equatorial belt, like the polar regions, is of particular interest to aeronomy and our scientific endeavour in diverse disciplines, if focussed in understanding the problems of equatorial aeronomy would not only be rewarding to the individuals concerned, but also be of great practical benefit to the nation".

The symposium discussed the following topics: The D-region at low latitudes; Ionospheric Absorption; Irregularities in the Equatorial Electrojet; Dynamo currents and Electric fields; The Neutral Atmosphere at Low Latitudes; Ionospheric Drifts at Low Latitudes; Ionospheric Irregularities; Equatorial F-region; Total Electron Content; Air Glow; Neutral particles and Ion-Chemistry; Dynamics of F-region; Ionospheric and Geomagnetic tides; Magnetic and Ionospheric Storm-phenomena in the Equatorial region; Exospheric Whistlers; Micropulsations; Magnetosphere and Solar-Terrestrial Relationships. Besides the formal sessions, there were many informal discussions.

An "Illustrated Abstracts" will be published to bring together the main ideas and results exchanged during the course of the symposium. ●

Watching fuel loading operations (below) at the Tarapur Atomic Power Station is Dr. K. L. Rao (dark coat) Union Minister for Irrigation and Power. He was taken around the Station on February 26 by the Project Administrator, Shri M. N. Chakravarti (second from right).



Centaure Rockets From Trombay

(*Continued from page* 1)

Centaure appears like a long graceful column, topped by a nosecone, about 300 mm in diameter and 6000 mm long from tip to toe, and having two sets of four fins each, one set in the middle and the other at the bottom.

The first stage motor is ignited by remote control from the Block House. The fuel block in it, termed "Venus", weighs about 100 kg. and burns off in about six seconds, releasing burnt gases under high pressure and temperature. Within a fraction of a second, the rocket clears the ramp, its flight stabilised at this stage by the spin imparted to it by the four small spin motors attached to the fins. A little after the first stage burns out, it is separated from the second stage (the upper one). The second stage motor then burns about 200 kg. of the solid fuel block termed 'Vega', in about 20 seconds, giving the necessary thrust to take the second stage with the payload to the required height. The fins in the first and the second stages maintain the spin already imparted by the spin rockets, stabilising the rocket alignment on its upward flight.

Demanding Job

The Centaure is a complicated piece of equipment involving a large number of special materials, from aero-spatial steel (for casings, fins, etc.) to items like explosive belt, igniter, thermal lining compounds, impregnated synthetic laminates, high temperature-resistant electrical cables, vibration-proof electrical connectors, special mechanical fastenings, a wide range of resins, elastomers, and a host of other items. Some of these have a very short shelf-life, while others need storage at temperatures ranging from —20°C to +5°C from the time they are prepared (in this particular case, abroad), to the time they are taken out for use during charging.

Besides these, a high degree of skill in assembling and treating some of the special materials is brought into play. The fin assemblies, for example, demand extremely close attention since accuracy in their assembly has a bearing on the stability of the rocket in flight.

In addition, within the two stages of the rocket, over a hundred heat-treated parts are involved. The long motor casings of both the stages involve numerous cycles of heat treatment. The temperatures and the time for heat treatment of the aero-spatial steel are quite critical and have to be kept within a very close range. In between the various cycles, the motor casings in the tough steel have to be worked with skill to remove distortions. At the Central Workshops, these challenging, intricate processes have been successfully gone through.

Besides, the fabrication work involves special kinds of welding, such as TIG welding with argon arc purge, resistance spot welding and plug welding etc. Such operations on aero-spatial steel, of circumferential and longitudinal high pressure joints in the rocket motor casings as also all other imported welding joints have to be subjected to cent per cent radiography.

At every stage of fabrication, rigid inspection and quality control has to be maintained : the electrical and pyrotechnical connections have to be tested for continuity with very low currents passing through them to avoid accidental explosions; every resin used for joints or for charging the rocket with powder blocks, is checked to ensure that it conforms to the design requirements; the explosive band for the interstage separation is checked for close contact and reliable functioning.

Apart from rocket fabrication, a complex for making the propellant and preparing powder blocks has been set up at Thumba in collaboration with Messrs Poudres of France. The first prototype blocks have been tested. A specially designed Charging Hall for charging these blocks has also been set up at Thumba.

Multi-Stage Rockets

A word about the hazardous and critical charging operations carried out in the Charging Hall. Charging of explosives involves manouvering of soft and heavy powder blocks in a skillful way. Sometimes, the powder blocks have to be chilled in a refrigerator and charged speedily to retain their shape. As most of the explosives and powders are sensitive to humidity, extreme care is essential while handling and storing.

The specialised technology and experience gained from the manufacture of the first batch of rockets at Trombay will be of use for fabricating multi-stage rockets of bigger dimensions to carry heavier payloads to greater altitudes in the near future. ●

mbay Centaures at Thumba

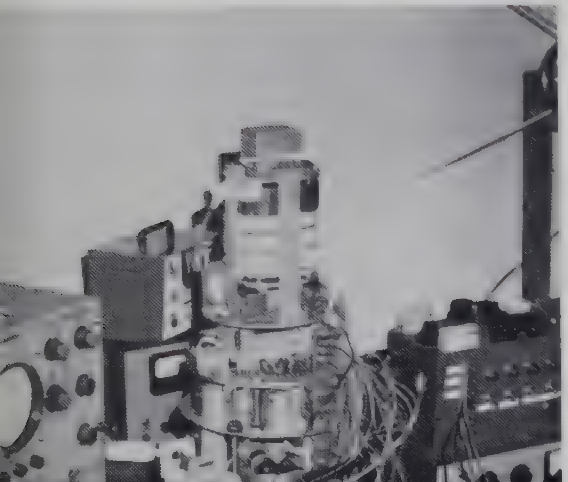
ft : Rocket Assembly shop at the Central Work-
of the Bhabha Atomic Research Centre, Trombay.

entre : First stage of Centaure, charged and
with nozzle.

ght : Centaures awaiting charging in the
ng Hall at Thumba.

: Centaure payload being checked.

right : Centaure ready for launch.



Interview: **Prof. Bernard Peters**

Cosmic Ray Research At the Tata Institute

IN cosmic ray research, Prof. Bernard Peters' name is always remembered for his discovery of the existence of heavy atomic nuclei in cosmic radiation while working at the University of Rochester, U.S.A.

To India, Prof. Peters is no stranger. He was here during 1950-58, working as Professor of Experimental Physics at the Tata Institute of Fundamental Research, Bombay. During this period, he played a major part in building up a group of young Indian scientists at the Institute, who were introduced by him to the intricacies and potentialities of cosmic ray research. His notable scientific contributions during this time are the exciting observations on the fundamental particles now called the K-mesons and the hyperons, and the initiation of the use of cosmic ray induced radioisotopes in the study of meteorology, oceanography, archaeology, etc. In 1959, Prof. Peters went to Copenhagen as Professor of Physics at the Institute of Theoretical Physics and is now the Director of Space Research in Denmark. He is a Fellow of the Indian Academy of Sciences and a Foreign Member of the Royal Danish Academy of Sciences and Letters.

Prof. Peters was one of the distinguished foreign scientists who participated in the Colloquium on "Cosmic Ray Studies in Relation to Recent Developments in Astronomy and Astrophysics," organized by the Tata Institute of Fundamental Research in Bombay last November. This interview was recorded by the editor at the time of the Colloquium.

Prof. Peters, you were associated with the Tata Institute as Professor of Experimental Physics during 1950-1958. Now, 10 years after your departure, could you please give us your impressions about the progress made in this area, here?

The Institute has grown considerably in the last ten years, both in size and importance, and in the diversification of the scientific work that is being carried out. I think the most impressive change is the quality of the younger research workers in the Institute. They seem to me much better qualified than the older generation which did not have the benefit of the developments which have taken place here since 1948 or 1950.

It is known that you were largely responsible for building up the group of cosmic ray researchers in the Institute. Could you reminisce on your stay here and your approach in selecting and organizing this band of worker?

It was initiated by Dr. Bhabha before I came here. It is true that during the years I spent here, the Institute took up many more problems and had considerable successes. I attribute this essentially to the devotion and intelligence of some of the people I already found here when I arrived. In particular, Prof. Daniel, Prof. Lal, Prof. Yash Pal and Prof. Sreekantan were already actively engaged as young research workers at the time I arrived here.

I understand that the Tata Institute's Cosmic Ray Group is among the largest and most diversified in the world. Could you name some of the subjects in this area wherein you think the Institute has contributed significantly, and which are the areas in which research here is most promising?

The Institute has made important contributions in studying the chemical composition of the primary cosmic radiation, both galactic and solar. It has made important contributions to our knowledge of the electron component in the primary cosmic radiation.

Some years ago, it had appreciable success in detecting the then new subatomic particles. It initiated at the time the technology of making three-dimensional emulsion detectors.

It was responsible for the fact that India was, after America, the first country to build and utilize on an extensive scale, plastic balloons for research at very great altitudes.

The Institute has a very strong air-shower group which has made useful phenomena at the limit of the known energy spectrum.

It has utilized a particularly favourable situation (a very deep mine in the Kolar Gold Fields) to make important studies on the muon component of cosmic radiation, and on the very difficult subject of high energy neutrino interactions. In fact, the Institute has one of two groups in the world whose work has contributed to what we know in this field at present.

The Institute has initiated a type of research which is now widespread over the world, namely, to utilize radioactive isotopes produced by cosmic radiation in the atmosphere. It has developed its own techniques of extracting these from rain water and from air, to detect these same isotopes in the oceans, in sediments, in polar ice and in other places. It has initiated the use of many of these isotopes as tracer elements in the study of geophysical and meteorological phenomena. At the time the Institute began this work, it was almost alone in the field, but today, there are many groups in the world occupied with this subject.

The Institute has lately entered the field of meteorites and is making studies in connection with the history of primary cosmic radiation and of solar activities many millions of years ago. It has made useful contributions in this field.

In earlier years, the Institute had great success in studying interactions of protons and pi-mesons at very high energies, and has contributed to the understanding of these very complex phenomena.

I think it is fair to say that no Institute in the world has worked successfully at so many different facets of cosmic ray physics as the Tata Institute of Fundamental Research.

It was during your Professorship, in 1953, that the fundamental particles K-mesons and hyperons were discovered here. Could you give us something of the background to this discovery? What led to it, and what is its significance?

The first discoveries of sub-atomic particles[*] directly produced in nuclear interactions were made in the laboratories of Prof. Blackett at Manchester and Prof. Powell at Bristol. The first examples of hyperons remained single observations for many years because the detection techniques were very cumbersome and the particles comparatively rare. The first K-mesons also remained a few isolated, not well-measured events until new technologies were developed. The success of the Institute in the field,[†] *i.e.* discoveries related to some of the new particles, such as accurate determinations of the energy release in the disintegrations, masses etc., was based on the very great attention which was paid to improving the technology of nuclear emulsions. In particular, constructing three-dimensional detectors with very accurate alignments, of the order of microns, which permitted tracing of these particles over large distances and measuring their properties over long track lengths, which had not been possible until then.

One should mention here also the development of the balloon flying techniques, which made it possible to expose such detectors at great heights under very favourable conditions.

During your 8-year stay in the Institute, you contributed towards the realization and initiation of the use in the study of meteorology, oceanography and archaeology. Could you briefly throw light on the impact of cosmic ray research in these fields?

I have already mentioned that this kind of work was begun in the Institute in 1955. Since then it has flourished and continues now under the direction of Prof. Lal. A contribution to our understanding of large scale meteorology was the study of the mixing of stratospheric with tropospheric air and the general problem of fall-out of radioactivity. Some work based on cosmic ray-produced radioactivity has been carried out on sedimentation rates in the deep oceans and on residence time of water at different depths in the ocean, and in different layers of the atmosphere.

I think it is difficult to make specific claims for this research; rather one could say that the experimental approach to the problems of large scale meteorology has been influenced by work which has been done at the Institute. The technique of isolating very small amounts of radioactive matter from large amounts of rain water has been greatly improved. New methods of sampling very large masses of ocean water by relatively simple techniques have been developed, and these techniques have found applications in studies elsewhere.

Is there any particular area in cosmic ray studies for which India is best suited, geographically?

I have mentioned before that India possesses one of the deepest mines in the world which permits the scientists at the Institute to carry out measurements on the muon component in an energy range which is not accessible to other laboratories. It also permits them to carry out high energy neutrino experiments under conditions which are more favourable than at any other place except for South Africa where there is a mine equally deep and equally suitable for such work.

Also, the location of India close to the equator has permitted a study of

(*Continued on page* 8)

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[*] pi-mesons, K-mesons, V-particles and hyperons were first discovered at Bristol and Manchester as heavy particles undergoing various types of decays in photographic emulsions and cloud chambers.

[†] The technique of putting together many separate thin layers of emulsion, that do not have any glass or plastic backing, to make up large emulsion blocks, was being developed simultaneously in several laboratories in the world (Bombay, Bristol, Washington). The first results relating to heavy mesons and hyperons using such "stripped" emulsion blocks were reported from the Tata Institute of Fundamental Research in 1953. There was the first decisive event corresponding to a negative K-meson that suffered nuclear capture on being brought to rest in the emulsion; accurate estimates were made of the energy release in the tau-decay through measurements of the ranges (and thereby of the energies) of each of the particles arising from the decay, since these could be brought to rest in the large emulsion block; observations were reported on the "associated" production of strange particles; as also observations on the decay of charged hyperons.

Prof. Peters on Cosmic Ray Research

(Continued from page 7)

very high energy cosmic ray phenomena with less background than one finds otherwise. It is true that other laboratories can do flights at the equator, but they have to make special expeditions, while the access here is easier for this type of study.

India has some of the highest rainfall areas in the world and this proved of use in understanding the fallout of radioactive ions produced by cosmic radiation. The fact that very arid areas and very rain-rich areas were accessible for these studies was of considerable importance in the early days of this development.

I can mention a few more examples of utilizing the special geographic conditions.

In recent times, a group at the Institute has become interested in X-ray astronomy. For this India is located favourably because it can see certain parts of the southern sky which is not accessible to many of the laboratories working in this field.

The radiotelescope which is being constructed at Ooty also makes use of the particular geographical position of India. It was possible to construct the array of radiodishes parallel to the axis of the earth, which is only feasible in equatorial latitudes. One of its programmes will be to study occultation of radio sources by the moon which permits precision measurements on the location and structure of these sources.

While working at the University of Rochester, U.S.A., you discovered the existence of heavy atomic nuclei in cosmic radiation. Could you tell us something of how this discovery came about?

It was the late Helmuth Bradt and myself at Rochester University who did the first work on this subject in collaboration with a group at the University of Minnesota. The technique of flying plastic balloons had just been developed and it was in fact, I believe, the first flight where such a plastic balloon which carried equipment to great altitudes was used for scientific purposes. We exposed nuclear emulsions there in order to study the pi-meson recently discovered by Powell, Occhialini and Lattes in Bristol. But we found in the emulsion also other interesting things, namely, tracks which we could not account for or identify until it dawned on us that they had an ionisation which was hundreds of times larger than that of particles which had been seen in emulsions before. We had taken great precautions to know the geometric positions of our detectors with respect to each other and with respect to certain structures in the payload. This permitted us to find out that these particles had a penetrating power vastly exceeding that of fission fragments which were the only very heavily ionising particles known until then. We came to the conclusion that we were dealing with a new phenomenon, a component of very energetic cosmic ray particles which have a large charge and therefore, presumably, were nuclei of heavy elements.

As Director of Space Research in Denmark, could you please explain the objectives of the Danish space programme?

The objective of the Danish space programme is in part technological, in the sense that the government would like to participate in the new technological developments of being able to carry out physical measurements at large distances from the earth. This involves, in the first place, the development of space craft; this task has been assigned to a collaborative enterprise involving ten European countries. On these satellites, individual research institutes can carry out space experiments. They build the apparatus to be flown in the space craft. The Danish government created an organization which could make use of such facilities—a space research institute. I have been active in it for the last two years. The Institute is primarily interested in exploring ionosphere, the magnetosphere and the regions outside of the magnetosphere. In particular it is concerned with low frequency electro-magnetic disturbances which arise by interactions with particles in the surroundings of the Earth and, perhaps on the Sun. The Institute is also interested in improving the technique of studying the chemical composition of primary cosmic radiation. Lately, it has begun a study of phenomena which connect low-energy particles in the equatorial belt and auroral phenomena in the polar zones.

What do you think are the areas of common interest in this field between India and Denmark?

Collaboration with my colleagues in India has never ceased. After I left India, I have been back here almost every year, some of my former students and collaborators have stayed in Denmark for periods of upto one year. We have always exchanged ideas, we have always exchanged technologies, and we have continued to write papers together.

The final question. With your absorption in the mysteries of the cosmos all these years, what do you think about the feeling in some quarters that there are intelligent beings, perhaps far more advanced than us, in our universe?

I think it is highly probable that a very large number of the 10 billion stars in our galaxy possess planets. I think it quite unlikely that among them there should be no other planets in which physical conditions are similar to our own. In view of the large numbers of stars which exist, my own guess is that life exists in many places in the Universe. I have of course no way of telling whether its evolution has taken a similar direction to the one it has taken here. I would be more surprised if we were unique than if there are many copies, many developments of a similar nature, both more advanced and more retarded than what we find here in our part of the Universe. ●

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NUCLEAR INDIA

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After the signing at Manila. The Foreign Minister of the Philippines, H. E. General Carlos P. Romulo stands in the centre flanked on his right by the Deputy Foreign Minister Jose D. Ingles, and the Philippine Atomic Energy Commissioner Pedro G. Afable. On General Romulo's left are: Shri A. S. Dhawan, Indian Ambassador to the Philippines, Dr. R. Ramanna, Director of the Physics Group of the Bhabha Atomic Research Centre, Mr. S. L. Chibber, First Secretary of the Indian Embassy, Manila, and Dr. P. K. Iyengar of the Bhabha Atomic Research Centre

India-Philippines Accord on Nuclear Energy

AN agreement to further cooperation in the peaceful uses of atomic energy was signed between the Governments of India and the Philippines at Manila on March 14.

The two countries are already successfully working together in the field of reactor utilization for pure research under an existing trilateral agreement which has the International Atomic Energy Agency as a party. Under the earlier accord, India provided a neutron crystal spectrometer on loan to the IAEA which is in use at the Philippines Atomic Research Centre in a Joint Regional Training and Research Programme being conducted by the two countries under the auspices of the IAEA. The spectrometer has now been gifted to the Philippines Centre.

Under the latest agreement, the two countries will cooperate in planning and executing collaborative programmes involving the use of research reactors at the Philippines Atomic Research Centre in Diliman, Quezon City, and the Bhabha Atomic Research Centre at Trombay, India. Among the areas in which the two countries will work together are: application of radioisotopes in medicine, agriculture, industry, engineering and general scientific research, uses of neutron crystal spectrometer and other facilities for the study of solid state and nuclear physics, development of nuclear electronics and instrumentation etc. The atomic energy establishments in the two countries will also exchange scientists, and scientific and technical information. ●

Report on 1968—69

Tarapur Station Marks Milestone in India's Nuclear Programme

NUCLEAR activities during the year reached a climax with the completion of India's first atomic power station at Tarapur. On April 1, atomic energy made its debut in the country as a source of electricity when power at low-level began flowing from the Tarapur Atomic Power Station. By July this year, the Station is expected to generate its full load of 380 MWe to the States of Maharashtra and Gujarat.

Besides completion of Tarapur and continuous progress in the construction of the two other nuclear stations in the country — the 400 MWe Rajasthan Atomic Power Station at Rana Pratap Sagar, and the first unit of 200 MWe of the Madras Atomic Power Station at Kalpakkam — there was considerable expansion of activities in other aspects of nuclear energy and space research during the year. The progress pattern in this period is indicated in the Report of the Department of Atomic Energy which was released this month.

The Bhabha Atomic Research Centre continued to assist the various nuclear and space projects besides carrying on its own diverse basic research and development activities.

The Isotope Division of the Centre sold isotopes, equipment and services worth approximately Rs. 22 lakhs. A total of 20,900 consignments of radioisotopes, labelled compounds and radiation equipment were despatched during the period. Out of this number, about 2,200 units valued at Rs. 2.59 lakhs were exported. Among

(Continued on page 4)

Course in Radiation Microbiology

A six-week training course in Radiation Microbiology sponsored jointly by the International Atomic Energy Agency and the Department of Atomic Energy commenced on April 7 at the Bhabha Atomic Research Centre, Trombay. It is being attended by 12 scientists from abroad and six from India.

Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre inaugurated the course. Shri Sethna said that the programme was specifically oriented to the applications of radiation microbiology in relation to food preservation and sterilization of bio-medical products, an area of major interest to most developing countries.

The following are excerpts from the Director's address :

"I think it will be appropriate if I say a few words on the significance of this subject—Radiation Microbiology.

Balance of Nature

"Microbes have always attracted the attention of scientists because they are one with us in our everyday life. They are responsible for the various biochemical and pathological processes in many living beings, including mankind. Microbes play extremely useful roles in the maintenance of the balance of nature. They actually participate in natural degradation of waste, enrichment of soil nitrogen and other beneficial biochemical processes in the living system. Harnessing of the by-products of microbial metabolism has resulted in large scale production of antibiotics; vitamins, alcohol, weak acids and various metabolites like glutamic acid, lysine, alanine etc.

"Most of you know that during the last decade, important discoveries in biology have become possible through experiments with microbes like the mold *Neurospora*, the bacterium *E. coli*, the bacteriophages like T_2, T_4, etc. These experiments have led to rational explanation of the mechanism of heredity and metabolic controls in the process of differentiation. It is strongly believed that the basic ideas established with the microbes can lead to similar discoveries in higher forms of life.

"There is a common fear that microbes are a source of danger to human health. This fear is not irrational. Several pathological conditions result from bacterial, viral and fungal infections.

Massive Radiation

"Commonsense tells us that elimination of the pathogenic and preservation of the beneficial organisms should be the objective. The application of massive radiation techniques, a by-product of the atomic energy development programme, has began to contribute a great deal towards preservation of food and sterilization of bio-medical products.

"Let me cite one example. Fish which forms an important source of protein food, decays in a few hours after catch if not stored in ice. This spoilage is essentially due to the microflora inside the fish. You will have adequate opportunities to see that by using massive radiation techniques we can in fact prevent the spoilage of fish and many other important sources of food.

"There are many challenging problems in this field. The present trends in the rates of growth of population and food production have brought to

(*Continued on page* 8)

Continued U. N. Sponsorship for TERLS

THE Scientific and Technical Sub-Committee of the U.N. Committee on Peaceful Uses of Outer Space, which met in New York on March 25, agreed to recommend continued United Nations sponsorship to the Thumba Equatorial Rocket Launching Station (TERLS) in Kerala. Sponsorship was first accorded to the Station in 1965, and the General Assembly renewed it in 1968.

Professor E. V. Chitnis, Secretary of the Indian National Committee for Space Research, who represented India, submitted a report on the activities of the Station. He mentioned that TERLS had been dedicated as an international facility on February 2, 1968. Among the activities in this area Prof Chitnis mentioned a meeting on equatorial aeronomy held from 3 to 10 February 1969 at Ahmedabad, and the launching of rockets bearing various types of experiments, including those dealing with vapour clouds, measurement of the composition of the atmosphere (with the cooperation of the Soviet Union), study of the ionosphere (including experiments conducted by a United States scientist), measurement of electrical fields (in cooperation with an institute in the Federal Republic of Germany), X-ray astronomy and cosmic radio noise.

Mr. A. W. Frutkin of the United States congratulated India on the "remarkable progress" shown by the Station, due largely, he said, not to international assistance but to "the local initiative exercised by India".

Mr. A. A. Blagonravov of the Soviet Union expressed complete satisfaction with the activities of TERLS, which he described as "a valuable contribution to the improvement of meteorological services throughout the world."

India-U.S. Draft

The recommendations on which the Sub-Committee reached agreement, were based on a working paper drafted by India and the United States.

The Sub-Committee also agreed to recommend, among other measures, the appointment of an individual, within the Secretariat's Outer Space Affairs Division, whose full-time task would be to promote the practical applications of space technology. Other recommendations concern possible panel meetings on specific topics, and encouragement of activities by the United Nations Development Programme (UNDP) to assist in promoting applications of space technology.

"How Green Is Our Revolution?"

Condensed from the First Lal Bahadur Shastri Memorial Lecture of the Indian Agricultural Research Institute, delivered at New Delhi on 7th April 1969.

by Dr. Vikram A. Sarabhai

Chairman, Atomic Energy Commission

AFTER successive years of serious drought, agricultural production in India during the past two years has staged a remarkable recovery, and, in many areas, has made what may well be regarded a breakthrough. Great credit for this must go to the agricultural scientists, the plant breeders, the increased supply of fertilizers, the sustained agricultural extension work which has been conducted over a period of time and the policy makers who have promoted imaginative programmes. The Indian Agricultural Research Institute has itself played a notable role under the leadership of Dr. Swaminathan. We now talk of a green revolution and look to it to transform our society. It is my purpose today to examine how green indeed is this revolution. Is power an essential ingredient for increasing agricultural productivity? Can the revolution sustain itself unless the Intensive Agricultural Development Programmes at the District level are backed up by equally imaginative action involving the Centre and the States co-operatively? Without an understanding of these matters, the green that we see would be like the green that suddenly appears on the landscape after the first showers in June, only to become brown again when the monsoon is delayed.

Agro-Industrial Complex

In considering these questions, I shall draw on studies conducted by the Indian Atomic Energy Commission related to the implications of an agro-industrial complex based on low cost energy centres. I shall also share some thoughts concerning change itself and the social and political environments in which things are likely to happen.

Recently, Professor Raj* has examined some questions concerning growth, transformation and planning of agriculture in the developing countries. He has, in particular, compared experience in Mexico, Taiwan and India (for the period 1952 to 1965). I realise that the study does not cover the past three years during which it is claimed that a qualitative change has occurred in Indian agriculture. Some of the conclusions he draws concerning the limited potential for new technology in non-irrigated lands may therefore require modification. However, the important point he notes is that in only three States, namely Punjab, Gujarat and Madras, did the compound rates of agricultural growth exceed by a good margin the rate of population growth. For the best of these, the performance is indeed comparable with the much praised results obtained in Mexico and Taiwan. On the other hand, in three of our most populous States, namely Uttar Pradesh, West Bengal and Kerala, we have a situation wherein population growth rate exceeds the rate of agricultural output. Raj concludes, and I quote:

> New varieties yielded more only with substantial complementary inputs of chemical fertilizers and other plant nutrients, and they in turn required assured supplies of water at specified intervals. Without such supplies there was danger of not only the complementary inputs becoming infructuous but, in some cases, of the yield being lower than from the use of the older varieties without applying these inputs.
>
> The percentage area of the land that can be provided with assured supplies of water imposes therefore a limit to the rates of growth that can be realised by technological change.

Almost two years ago, the Atomic Energy Commission of India initiated a study to explore the implications of abundant low cost power to agriculture. It had the benefit of a similar study conducted by the Oak Ridge National Laboratory of the U.S. Atomic Energy Commission. A number of major electricity consuming outlets such as electro-chemical and electro-thermic processes and pumping of underground water through tube wells have been examined in addition to desalination of water. This is to ascertain whether by a careful choice of energy consuming projects related to a low cost energy producing centre, one could provide not only fresh inputs for economic development, but a balanced load within the grid system.

In areas where underground water is available in plenty like in the Western Indo-Gangetic region of Uttar Pradesh, the use of low cost electrical energy for lifting water along with modern agricultural methods can make a crucial difference to the profitability of farming and will have a great impact on the economy of the country.

Nuclear Power Economical

The detailed implications of the Agro-Industrial-Complex have been evaluated for a region of western Uttar Pradesh. The area covers a population of 23.6 million people. It has Delhi to the west, Agra to the south and the Ganges flowing through the middle. There is a large amount of underground water and the soil is mostly alluvial in character. A suggested installation involves a power station with two nuclear reactors each of 600 MWe capacity. This is because in this region nuclear power would be more economical than thermal power. A fertilizer plant of total capacity of 4,500 tonnes per day and an aluminium plant of 150 tonnes per day are envisaged with approximately 200 MWe used for lift irrigation through 36,000 tube wells.

(Continued on page 7)

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* "Some Questions Concerning Growth, Transformation and Planning of Agriculture in the Developing Countries" by Prof. K. N. Raj, Delhi School of Economics, published in Vol. I, No. I of the Journal of Development Planning, April 1969, Centre for Development Planning of the United Nations.

Fast Reactor Research Centre for Kalpakkam

(Continued from page 1)

the countries which bought the Centre's radioisotopes and equipment are Australia, Burma, Ceylon, Denmark, France, Kuwait, Korea, Lebanon, Rumania, Taiwan, Thailand and the UAR. The Centre, incidentally, has been regularly supplying radioisotopes for medical use to hospitals in Australia, Burma and Thailand.

Among radiation equipment sold, mention may be made of a gamma irradiation unit, "Gamma Chamber 900", exported to Lebanon and Rumania. Also, a 5,000-curie panoramic irradiator was exported to Taiwan, against an order received from the International Atomic Energy Agency.

Besides production of radioisotopes and equipment, the Centre continued research and development work relating to applications of atomic energy in agriculture, industry, medicine, biology and other areas.

Food Preservation

The Biology Division continued its plant breeding programme, among other investigations. Promising mutants of rice and groundnut developed by it are currently being subjected to field trials under the All-India Coordinated Improvement Project for Rice and Groundnut. A collaborative programme of work with the Central Rice Research Institute, Cuttack, has also been taken up to induce dwarf mutants in otherwise potentially high yielding varieties of rice.

Work on development of radiation preservation procedures for perishable foods was intensified at the Food Irradiation and Processing Laboratory of the Centre. With the completion, more or less, of the facilities at the Laboratory, experimental programmes have been accelerated. Large scale studies with mangoes and sea food (Bombay duck, shrimp and pomfret) have yielded promising results.

Activities relating to radiosterilization of medical supplies were also undertaken and facilities were made available for exposing other products to gamma rays. Plans have been completed for large scale feasibility studies on grain disinfestation by gamma rays in collaboration with the Directorate of Storage and Inspection, Department of Food, Ministry of Food and Agriculture.

The Food Irradiation and Processing Laboratory at Trombay.

At the Fuel Element Fabrication Facility of the Centre, development work connected with the fabrication of fuel elements and components for future nuclear power stations was continued. The Facility meets the requirements of metallic fuel elements and sub-assemblies of the Cirus and Zerlina reactors at Trombay. During the year it took up the work of fabricating fuel elements for a zero energy reactor to be set up at the Indian Institute of Technology, Delhi. Besides, it continued the production of high density sintered UO_2 pellets. The Facility is also fabricating the initial half charge for the first unit of the Rajasthan Atomic Power Project.

In the field of fast reactors, work was done at the Centre on the design of the Indian Fast Test Reactor and a pulsed reactor. Detailed analysis was made on the physics experiments carried out abroad. The Experimental Reactor Physics Section at the Centre directed its efforts towards the setting up of experimental techniques for subsequent use in the study of power reactor configurations.

Planning for the Fast Reactor Research Centre at Kalpakkam was initiated. The design of the engineering laboratories has been finalized and it is expected that the laboratories will be commissioned some time next year.

The Electronics Division of the Centre designed and built an electronic digital computer, TDC-12. This fast computer is capable of performing 250,000 additions and subtractions in a second, and is intended for real time applications. This is the first real time digital computer developed in the country. Commercial production of this computer will be taken up by the Electronics Corporation of India Ltd., at Hyderabad.

The Electronics Division also completed the fabrication of 107 single units, 13 counting systems, one analyser, 41 installations and 470 counters and dosimeters. The cost of this instrumentation is estimated at Rs. 11 lakhs. In addition, a production line has been initiated for 150 oscilloscopes to meet Defence requirements.

Nuclear Explosions

Measurements were continued at Bombay and ten other stations in the country for bomb-produced radioactivity in the atmosphere and in surface deposits. Analytical work on various food samples from Bombay, and milk samples from countrywide stations for Cs^{137}, Sr^{90}, K^{40} was undertaken.

At Gauribidanur in Mysore State, normal operation of the Seismic Array was maintained and valuable data on several underground nuclear explosions as well on earthquakes was gathered. The Station has also been provided with devices for detecting nuclear explosions in the atmosphere.

Consistent with the policy of deveoping indigenous know-how for nuclear power generation, work on engineering systems for Unit II of the Rajasthan Atomic Power Project has been undertaken by the Bhabha Centre and allied organizations.

About 100 new institutions, representing nearly 1,500 radiation workers, joined the Film Badge Service of the Directorate of Radiation Protection during the year. The service now covers 1,110 institutions and monitors a total of nearly 13,500 radiation workers in the country. The Directorate has also developed and built a wide variety of instruments, most of them specially suited for work under the widely varying climatic conditions encountered in field use. The Electronics Corporation of India Ltd. at Hyderabad is mass producing some of the instruments developed by DRP.

A Training Division was formed in May 1968 to coordinate the various training activities in the Centre. In order to meet the growing demand for trained scientists and engineers, the number of trainees is being increased to 250 per year. The Training Division has arranged practical training in the Centre for some of the engineering students from the various IITs and engineering colleges, as part of their curricula.

Tata Institute of Fundamental Research

At the Tata Institute of Fundamental Research, an on-line data processor (OLDAP) designed and built in the Institute is undergoing final tests and is expected to be commissioned in the middle of 1969.

In Medical Electronics, the Institute has developed a device for monitoring the degree of variation of energy associated with the electrical activity of the brain. This equipment would be of help in the diagnosis of diseases such as epilepsy and schizophrenia.

The National Computation Facility at the Institute, based on the CDC 3600-160A computer system, completed its fourth year of operation.

Studies, both experimental and theoretical, on the primary Cosmic Radiation are continuing. Balloon flights are being made from Hyderabad on a regular basis for the study of cosmic X-rays, gamma-rays, electrons and multiple charged nuclei; the balloons manufactured in the Institute have volumes upto 85,000 cubic metres, and have reached altitudes upto 37 km with payloads.

A large area multiplate cloud chamber is being operated in conjunction with the Extensive Air Shower Array at Ootacamund; about 5,000 cloud chamber photographs of the central regions of airshowers have been recorded and are being analysed.

Considerable progress was made in the setting up of the 530-metre long cylindrical radio telescope at Ootacamund for studies in Radio Astronomy. The telescope is expected to be completed during 1969. Electronic equipment, fully designed and fabricated at the Institute is being installed at the site.

The Homi Bhabha Auditorium and Museum of the Institute was inaugurated by the Prime Minister, Smt. Gandhi, on 9th November 1968.

Physical Research Laboratory

The Physical Research Laboratory (PRL) continued its studies of the electromagnetic and particle emissions from the Sun, and their interactions with earth's atmosphere. These involved ionospheric soundings, measurements of ionospheric drifts, ionospheric absorption, geomagnetic field changes, ozone and airglow as well as solar radio fluxes. Ground-based observations were taken in all these areas from Ahmedabad as also at a few of these areas from Trivandrum.

Measurements of electron densities and electron temperatures of acoustic-ionic waves, electric currents, electric fields, and of upper winds were carried out with rocket-borne payloads. The payloads were fabricated at PRL, mostly with indigenous materials and flown on rockets launched from the International Equatorial Rocket Launching Station at Thumba (TERLS). Payloads for the measurement of X-ray emissions from stars were also successfully rocket-borne from Thumba, during the year.

The investigation of time variations in cosmic ray intensities was continued. Significant results were obtained in this field suggesting that some of the variations are related to variations in the conditions of interplanetory space caused by particle emissions from the Sun. The Physics of the plasmas and the structure of nuclei were the two areas of main interest to the PRL group on Theoretical Physics.

The Saha Institute of Nuclear Physics at Calcutta is collaborating with the Bhabha Atomic Research Centre for building a Variable Energy Cyclotron near Calcutta.

Space Programme

In the Space Research Programme, upto January 31, 18 rockets (12 Nike-Apaches, 4 Centaures and 2 Arcas) were launched from Thumba. Apart from exclusive experiments, scientists from PRL and TERLS collaborated with scientists from the USA, West Germany, Japan and the USSR in different experiments during the year.

A series of rockets under Project Rohini is under development at the Space Science and Technology Centre. One 2-stage Rohini rocket and eleven Rohini RH-75 rockets were flight tested during the year. TERLS also continued development of the Menaka meteorological rockets.

India-built Centaure rockets are being flight tested currently. A Rocket Fabrication Facility is being added to the Thumba set up.

Work at Arvi on the Commercial Satellite Communications Earth Station for the Overseas Communication Service is progressing The Station is expected to be ready by October 1969.

Atomic Minerals

The Atomic Minerals Division of the Department achieved further progress in the underground development work at the Narwapahar and Bhatin deposits and in the assessment of nickel and molybdenum reserves at Bhatin.

The Indian Rare Earths Ltd. pushed through its plans for diversification in its Rare Earths Division. For the first time, the Company is attempting

(Continued on next page)

Heavy Water Plant at Rajasthan Atomic Project

(Continued from page 5)

to separate yttrium from a small portion of the rare earths chloride manufactured by it.

For the first time also, the Company sees signs of being able to export a sizeable quantity of rutile. It may be recalled that hitherto rutile has always been imported, and the present export is a notable trend.

All the major construction and erection works of the Uranium Corporation of India Ltd. at Jaduguda have been completed. The Uranium Mill was commissioned for commercial production in May 1968 and the value of finished products till November 1968 is estimated at Rs. 100 lakhs.

A Nuclear Fuel Complex at Hyderabad is being set up with the object of attaining self-sufficiency in fuel element supplies for the country's nuclear power programme.

Heavy Water Plant

At the Electronics Corporation of India Ltd., Hyderabad, there was steady progress in the production of the following new items: (i) Components such as carbon and metal film resistors, tantalum capacitors, germanium power transistors, zener diodes, silicon rectifiers, thermoelectric modules etc. (ii) Nuclear instruments for medical, agricultural, research and industrial purposes and (iii) Instrumentation and controls for nuclear power stations. A separate unit of ECIL, known as the Power Reactor Instrumentation Division undertakes work of fabrication and assembly of control panels, consoles and instruments for nuclear power plants.

It is proposed to set up a Heavy Water Plant alongside the Rajasthan Atomic Power Plant to produce 100 tonnes per year of nuclear grade heavy water.

As mentioned earlier, the Bhabha Atomic Research Centre will be building an AVF Variable Energy Cyclotron at Calcutta during the Fourth Five Year Plan period in collaboration with the Saha Institute of Nuclear Physics. The cyclotron will be built indigenously, only the very basic components being imported.

A project for nuclear research in agriculture under the auspices of the United Nations Development Programme (Special Fund) started functioning at the Indian Agricultural Research Institute, New Delhi. The purpose of this project is to expand research and training facilities for radiation applications in agriculture at the Indian Agricultural Research Institute and at three other Centres — the Bhabha Atomic Research Centre, Trombay, the Indian Veterinary Research Institute, Izzatnagar, and the National Dairy Research Institute, Karnal.

A Working Group set up by AEC has completed a preliminary study on (i) the impact of low-cost nuclear energy on certain major power consuming industries; and (ii) the potentialities of agro-industrial complexes in regions such as the Indo-Gangetic Plain and the Kutch-Saurashtra region. The Working Group has submitted its report.

Financial assistance to the extent of Rs. 12.5 lakhs was sanctioned to various universities and institutions for work on projects related to nuclear sciences and allied disciplines. ●

Madras Atomic Power Project. Reinforcement grill being lowered for diaphragm wall of the reactor building.

'Development Involves Many Disciplines'

(*Continued from page* 3)

The total investment of the project is about Rs. 429 crores. The return on this investment is expected to be about 14%. In arriving at this evaluation, differential tariff rates of 2 p/kwh for fertilizers, 2.6 p/kwh for aluminium and 10 p/kwh for tube wells have been assumed. At this power cost for fertilizers, the project is comparable to a similar one based on coal even at a pithead coal price of Rs. 35 to Rs. 40. Though the power cost for the tube wells has been taken high, still the agricultural project gives sufficiently high returns. Approximately 720,000 hectares are proposed to be irrigated under this project. The total incremental cereal production would be 4.5 million tonnes and in addition 700,000 tonnes of pulses would also be produced. The implementation of the project would result in an increase in the per capita income in the area to the extent of Rs. 150 per annum, or about 20%. The per capita income of persons directly engaged in the project would increase by about Rs. 1400 per annum. The project by itself would contribute Rs. 486 crores to the GNP.

A Dependable Source

Since only about 50% of the fertilizer production is utilised within the complex, the balance would be available for use outside. The benefits derived from this by way of increased food production, increased GNP, increased per capita income, etc. though quite high, are not included in the above figures. If we assume the same yield rates outside, the additional increase in GNP on crops will be of the order of Rs. 400 crores (@ Rs. 5000/hectare for 0.8 million addl. hectares).

If the area under the project is considered as a food factory, the surplus food production in the region can be a dependable source for food grain for procurement purposes. In a limited region, the procurement would be easier and can be efficient as compared to the country-wide efforts required today.

A plan of this type can be implemented in phases. While the nuclear power plant of large capacity may take 5 to 6 years to complete, the pumping sets could be energised much earlier through the installation temporarily of smaller conventional power units such as gas turbines feeding from District centres. These District centres would ultimately be connected with the main grid and the power plants could be moved to new locations. When one considers that the most important tasks faced by India are to increase per capita income and to grow sufficient food for a growing population, it is clear that the establishment of such projects is of great significance.

Effort at National Level

How is such a plan to be implemented? It requires effort at the national level, since the setting up of atomic power stations is a responsibility of the Central Government. Moreover, a station as large as one generating 1000 MW of electricity, would have to be part of a super grid connecting the important generating points feeding six States. Each State would have to gear its own electricity plan to take up and distribute power to the points at which tube wells would require to be constructed and energised. There would need to be local organisations for digging the tube wells on a cooperative basis and for maintaining them in good working condition. There would be need for hardware — the cables, the distribution towers, switch gear, pumping sets, pipes for the tube wells. Unless everything in this total framework, from the mining of uranium to the production of the nuclear fuel elements and the heavy water, the fabrication of the equipment for the nuclear power stations, its erection and commissioning can be phased with the erection and commissioning of the fertilizer complex and the lift irrigation system, one cannot hope to achieve the results that the system as a whole is capable of providing.

Development involves many disciplines and many levels of political and administrative decision making. The agricultural development of western Uttar Pradesh would be dependent for its power needs on the northern grid and cooperation between the Centre and the various States which are related to this grid. For fertilizers it would be related to some Central, perhaps some State supported and some private enterprises. It would obviously be impossible to expect that all these operations, of generating power, of producing fertilizers and of distributing electricity should be under one authority. But we do require to mobilise all the functions for a particular task through entrusting the management responsibility to a single administration relating itself separately and at different times with different organisations as need may arise. The T.V.A. project in the United States is an outstanding example of the manner of dealing with the problems of development of a region as a whole, independent of State frontiers. Attempts have been made from time to time in this country to follow the same philosophy. I am of course aware that many of these have run into difficulties and the idea is often viewed with cynicism. But if we wish our green revolution to take root, there is no alternative but to examine our mistakes in the past and continue to develop our skills to make such structures work.

Professor Raj has observed, and I quote:

> Clearly, if the areas in which the technology can be rapidly transformed are limited by inadequate supplies of water, the case for making the most efficient use of resources in the regions in which such transformation is possible (as well as elsewhere) becomes even stronger than otherwise. This is where the need to make institutional changes in agriculture comes in.
>
> This aspect of the problem has been getting increasingly neglected in recent years in the belief that techno-

Need to Examine Our Mistakes in the Past

(Continued from page 1)

logical changes in agriculture can by themselves yield high rates of growth and that, since institutional reforms call for strong political action that might meet with resistance, it is wiser to concentrate on the former.

Unless planning, management and organisation are put on a sound basis, there is little hope of our fulfilling expectations aroused by the green revolution. It is important to assess the minimum critical effort required to produce a permanent change, for it is not as if with small effort we can produce a small change. When we have, as in this country, many desirable things to accomplish and large areas to be covered with limited resources, one is apt to regard that spreading effort widely, even though thinly, is the most sensible thing to do, since it appears to satisfy a social objective. In fact, what we generally do, through such a process, is to stall completely the take off, so that historical and unorganised rather than consciously planned factors determine the unfolding of events.

Selective Approach

We see clearly the relevance of a selective approach which requires effort in each case on a decisive scale, permitting the direct benefits to be given to different areas only in succession rather than through simultaneous action throughout the country at a level so feeble that the impact is scarcely made.

As Raj has observed: "The availability of modern technology leads very often only to dualism in the agricultural sector (as in Mexico) rather than to transformation of traditional agriculture". In a democratic society, to adopt policies which involve a selective approach is undoubtedly difficult. It should, however, be possible to do so if the economically most backward areas are the objects of discernible and highly preferential treatment by the State. Criteria for selection based on the single minded pursuit of optimisation of growth with a given effort can only increase the gap between the rich and the poor sections of the nation, jeopardising internal security.

The order in which things are put together plays an important role in determining the final properties of an aggregate. This can be observed even in inanimate molecules like the sugars where those with atoms arranged along a right handed screw have different properties from the compounds with a left handed arrangement. This is particularly so in the context of social change where the sequence of events is crucial to the realisation of an end objective. A clear appreciation of this is vital for the management of our green revolution at various levels.

An agriculturist dealing with biological systems knows only too well that unless appropriate inputs are made at appropriate times, growth can be inhibited. Social systems react similarly. The influence of a stop-go policy in providing support to organisations for development can be equally deliterous.

The establishment of the package programmes for agriculture is itself a recognition of many of these factors. Effort is concentrated in a given area where one is trying to provide all the inputs that are considered necessary. It is recognised that as new practices get accepted, effort from outside can be on a reduced scale and fresh areas taken up. The package programme involves an imaginative and what was at the time an unconventional approach to the problem of increasing food production. The question is: Is it sufficient to carry us forward ? What do we have at the State or the national levels as counterparts ? ●

Radiation Microbiology Course at Trombay

(Continued from page 2)

the forefront an alarming divergence. There are some who believe that all efforts should be directed to increased food production. An increment in input does not always result in an increment in output. In fact there comes a stage when a quantum of input effort does not add to the output. The input cost in terms of money and human effort, for a unit increment in food production is both large and recurring.

"It is therefore imperative that we should make sustained efforts to save what we produce. Neglect of this aspect would neutralize the small gains which accrue from increased food production. The methods of radiation pasteurisation and radiation sterilization of insect pests from food grains have opened up possibilities of food preservation. It is up to us to exploit these potentials to make a 'hunger-free world' of tomorrow."

Earlier, welcoming the participants, Dr. A. R. Gopal-Ayengar, Director of the Bio-Medical Group at the Bhabha Atomic Research Centre expressed his gratification that a number of scientists from developing nations in South East Asia, West Asia, Europe and Latin America were attending the Course. He said the basic difference between developed and developing nations was not the lack of resources in materials and men but one of initiation in the exploration of science and technology to human advancement. In the last decade or so, he said there had been an awareness of this aspect. Thirty years ago, science and technological know-how was the prerogative of developed nations. At that point in history, nations were either developed or underdeveloped. With the unrelenting efforts of a number of international organizations and the IAEA, in particular, in the field of atomic energy, this distinction, he added, had slowly and steadily transformed. No nation today can afford to neglect science and technology. "It is to national economy something like salt in your food." ●

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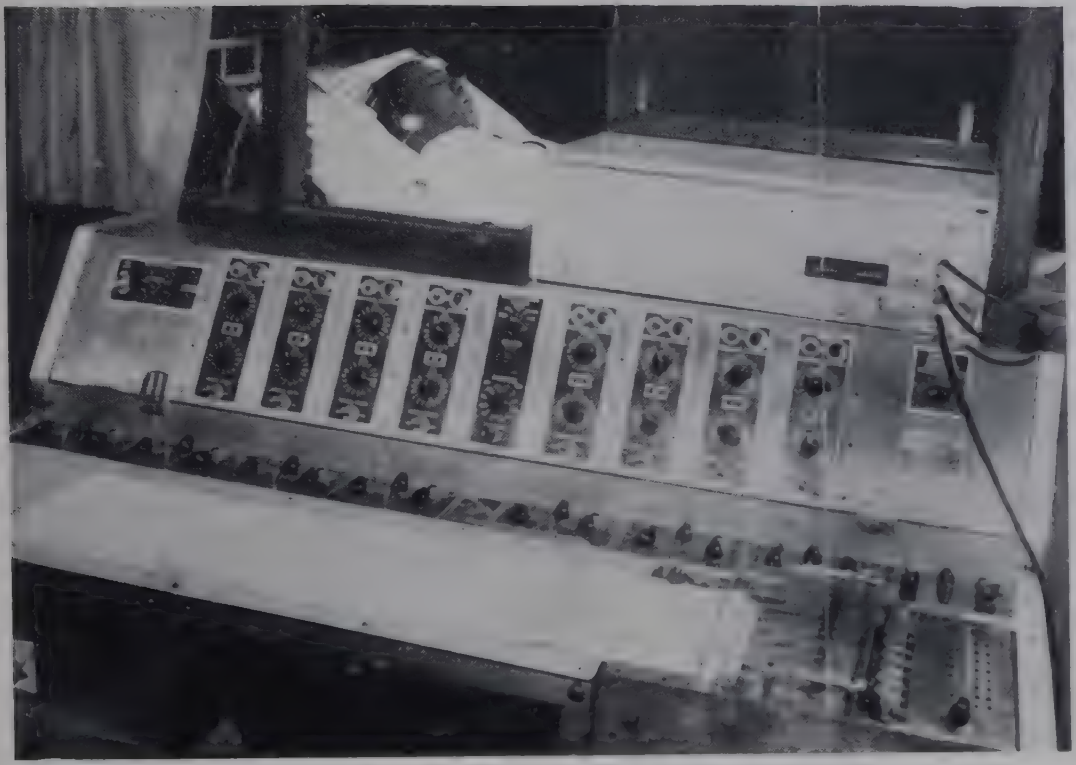

The Energy Monitor (rectangular box), connected to the EEG Machine (console in the foreground) and under test at the K.E.M. Hospital, Bombay. Subject under test can be seen in the background.

TIFR Develops Energy Monitor for Medical Use

A device for monitoring the degree of variation of energy associated with the electrical activity of the human brain has recently been developed by the Computer Group of the Tata Institute of Fundamental Research, Bombay. As is generally known, Electroencephalogram (EEG) is the name given to the recordings of electrical signals picked up on the skull. These signals are the result of complex electrical activity taking place in a large number of individual nerve cells. EEG tracings are, therefore, very difficult to interpret directly. Measuring the electrical energy — as the newly developed unit does — would be necessary to gauge the amount of brain activity and its variation with time.

It has been pointed out by groups working in this area in the United States of America that the degree of variation of energy of electrical activity in the brain is a useful index of the subject's brain function. Schizophrenia, for instance, is a disease which has been reported to be associated with hyper-regulation of energy monitored by EEG — that is, a pronounced decrease in its time variation. Similarly, drugs such as LSD, which cause conditions resembling schizophrenia, are known to cause similar deviations from normal brain activity. Epilepsy is also believed to cause complex but observable effects in the nature of energy regulation. The Energy Monitor has been designed to measure energy more directly and accurately than earlier instruments which are in use elsewhere, and is expected to help medical workers interested in diagnostic problems in these areas.

see also pages 6 & 7

The Energy Monitor creates a sequence of electrical pulses, providing a measure of the energy in the electrical activity of the brain at any time. These are conveniently recorded on the standard EEG machine along with the conventional EEG traces. Computer analysis of the recorded data provides for speedy calculation of an index representing the energy variation. This calculation can also be done manually.

The Energy Monitor that has been developed at TIFR is transistorised, portable and self-contained, and can be directly attached to any standard EEG machine.

The Department of Psychiatry of the K. E. M. Hospital, Bombay, is currently testing the unit in collaboration with TIFR staff.

Rocket Launching Station on East Coast

A decision has been taken to establish a second rocket launching station in the country. This station, which will also function as a satellite launching base, will be set up on the east coast of India, on Sriharikota Island in the Nellore District of Andhra Pradesh.

The first rocket launching station, at Thumba in Kerala State has been in operation since 1963.

An east coast range would also be very advantageous for launching satellites. The Sriharikota Island station will be used for testing rockets developed at the Space Science and Technology Centre at Veli Hill, Thumba.

With the second station, India's capability for space research will be greatly enhanced.

Operating floor of reactor building of the Tarapur Atomic Power Station

Full Power from Tarapur Atomic Station in July

TARAPUR is expected to begin generating its full load from July this year. It may be recalled that the original schedule of commissioning, October 1968, had to be revised because of defects which were detected during prefuel-loading tests. The defects have since been removed and detailed operational testing is now on.

Fuel was loaded in the first reactor on February 1 and in the second reactor on February 21 this year. Reactor No. 1 became critical on February 1 while reactor No. 2 reached criticality on February 27. Power started flowing from reactor No. 1 on April 1 and from reactor No. 2 on April 22.

Stringent Supervision

The loading operations call for very stringent supervision and a series of tests have to be conducted at different power levels. Simultaneous with the testing operations, power was also fed into the grids to partially relieve the power shortage in the region at that time. So far 13 million units of power have been produced from the first reactor of the station, and 9 million units from the second. The supply is necessarily intermittent as the reactors have to be shut off on different occasions for intensive checking at every stage. The raising of power in the reactors from zero level to various intermediate higher levels, checking of the systems for defects not only when the reactors function continuously but also during deliberate reductions of power, rectification of defects, if any, and stepping up of the power level gradually are part of the start-up programme in any nuclear power station. The checks and the measures taken are part of normal precommissioning operation. The testing programme has proceeded quite satisfactorily.

●

BARC Reporting

Waste Treatment Division

Special air filters were supplied to the 'Videsh Sanchar Bhavan' of the Overseas Communications Service at Bombay last month. The cost of production of these totally indigenous filters is Rs. 30,000. The total cost of equivalent imported filters would be Rs. 37,200 with a foreign exchange component of Rs. 21,000.

Isotope Division

The sale value of radioisotopes, equipment and services rendered during April 15 — May 15 totalled Rs. 1.52 lakhs. A total of of 1,431 consignments including 917 for medical use were despatched.

A total of 200 consignments valued at Rs. 9,600 were exported to Australia, Burma, Denmark, Korea, Thailand and Turkey.

Radiotracer studies were conducted in two oil wells at Ankleswar oil fields for the study of the pattern of entry of injected water into the wells.

Radiography work for the inspection of certain heavy castings required at RAPP has been taken up.

Directorate of Radiation Protection

Upto May 15, the countrywide film badge service covered a total of 7,985 workers from 985 institutions. Radiological protection surveys were conducted in eight institutions to assess the extent of radiation hazards and to recommend suitable measures to reduce them. The 19th four-week training course on "Safety Aspects in the Medical Uses of Radiation" commenced on May 6, 1969. Twelve candidates including radiologists, physicists and other research workers are attending this course.

Genius of the Periodic Table

"Isn't it the work of a genius" exclaimed Academician V. I. Spitsyn, USSR, a member of the Scientific Advisory Committee when talking to an IAEA audience in January. His listeners shared his enthusiasm. Academician Spitsyn was referring to the first formulation, a hundred years ago, by Professor Dmitry I. Mendeleyev of the Periodic Law of Elements.

IN conditions of enormous difficulty, considering the lack of data on atomic weights of elements, Mendeleyev created, in less than two years work at St. Petersburg University, a system of chemical elements that is, in general, still being used. His law became a powerful instrument for further development of chemistry and physics. He was able immediately to correct the atomic weight numbers of some elements, including uranium, whose atomic weight he found to be double that given at the time. Two years later Mendeleyev went so far as to give a detailed description of physical or chemical properties of some elements which were as yet undiscovered. Time gave striking proof of his predictions and his periodic law.

Mendeleyev published his conclusions in the first place by sending, early in March 1869, a leaflet to many Russian and foreign scientists. It gave his system of elements based on their atomic weights and chemical resemblance.

On March 18 that year his paper on the subject was read at the meeting of the Russian Chemical Society, and two months later the Society's journal published his article entitled "The correlation between properties of elements and their atomic weights". In the article, Mendeleyev's first formulation of the Periodic Law was: "Elements arranged in accordance with their atomic weights display a marked periodicity of properties". Later he gave it with even greater precision as: "Properties of elements as well as forms and properties of their compounds are in a periodic dependence on the atomic weights of the elements".

Although previous attempts had been made to classify elements in groups and tables, this was the first elucidation of the general relationship between the properties of all known chemical elements. The outstanding importance for the philosophy of science lay primarily in the fact that it disclosed the existence of an interrelation among all chemical elements, their physical and chemical properties. The groups and series of the system could now be used as a firm basis from which to identify families of related elements.

Among elements predicted by Mendeleyev and afterwards discovered were those now known as gallium, scandium, germanium, radium, actinium, polonium (all found during his lifetime), technetium, rhenium, francium and protectinium.

The Periodic Law extended to compounds of elements, melting points of elements and metal chlorides, the structure of spectra, and magnetic properties. Mendeleyev continued to work on it for close on forty years, his last variant of the table being prepared shortly before his death in 1907.

New Elements

After reviewing the great pioneer's work, Academician Spitsyn dealt with its effect on studies of the structure of matter. It played an important part in elucidating the phenomena of radioactivity, transmutation of elements by decay and led to the discovery of isotopes. As theories of atomic structure were developed, they served to give further validity to Mendeleyev's law. Steadily the blank positions in his table were filled in as new elements were found, until in 1947 the finding of promethium completed the list between hydrogen and uranium. Formerly it was considered that there could be no more. But in fact twelve "transuranic" elements have to date been isolated through the use of powerful modern accelerators. Element 101 was named mendelevium in recognition of the man whose system for predicting properties of undiscovered elements had provided the key to the discoveries.

For producing the transuranic elements in quantity the usual procedure starts with irradiating uranium, enriched uranium or plutonium in a reactor. For some of them, however, underground nuclear explosions are a method, though the problem then exists of isolating elements or their isotopes from a great mass of molten rock. Scales of production vary considerably. Annual world manufacture of plutonium amounts to many tonnes; other figures are tens of kilogrammes of neptunium, tens or hundreds of grammes of curium, milligrams of berkelium and californium, microgrammes of einsteinium and fermium, and only trace amounts of mendelevium, the unnamed element 102 and laurencium.

In dealing with aspects of continuing research and discoveries Academician Spitsyn emphasized that much of it is based on, or alternatively provides, further exemplification of the Mendeleyev law. (*Reprinted from IAEA Bulletin Vol.* 11, *No.* 2, 1969)

New Laboratory at Thumba

The Chemical Laboratory of the Propellant Engineering Division at Veli Hill, Thumba, was inaugurated by the Chairman of the Indian National Committee for Space Research (INCOSPAR) Dr. Vikram Sarabhai on April 17. Located in one of the new buildings of the Propellant Complex coming up at Veli Hill, the well-equipped laboratory will serve all the units of INCOSPAR at Thumba and Veli Hill. It is an important facility for work connected with propellant research and processing, binder development and production, fine chemicals, etc.

ATOMIC MINE

AMONG the tasks assigned to the Indian Atomic Energy Commission when it was set up in August 1948, was the survey and development on an industrial scale of atomic minerals in the country.

Exploration for and production of uranium, thorium, beryllium, zirconium, titanium, collumbium-tantalum and the rare earths is the responsibility of the Department of Atomic Energy. The Atomic Minerals Division, the Indian Rare Earths Ltd., and the Uranium Corporation of India Ltd., are the organizations under the Department which carry out the diverse tasks in this area. The Atomic Minerals Division conducts surveys, prospects and develops the minerals especially uranium; the Uranium Corporation of India Ltd., undertakes industrial exploitation of the mineral, while the Indian Rare Earths Ltd., develops and processes monazite reserves for extracting rare earths and thorium.

The distribution and development pattern of the major minerals, mainly uranium and thorium, is along these lines:

Uranium: In the north-east of India is Bihar, the richest mineral State in the country. It has all along held the first position in the value of mineral production and now holds the premier position in respect of most of the atomic minerals, particularly uranium.

Since the early Fifties, intensive exploratory work for uranium, aided by laboratory research has been going on in the Singhbhum Thrust Belt of this State. This Belt, also known as the Singhbhum Copper Belt, has perhaps the highest potential for deposits in the country. Here uranium mineralization is associated with copper, and, occasionally, with nickel and molybdenum.

In the middle of this belt, lies the richest deposit in the country, at Jaduguda. After exploratory core-drilling and extensive underground development, full scale mining has recently been undertaken by the Uranium Corporation of India Ltd.—a government-owned concern set up in October 1967. A Uranium Mill close to the mine site, is extracting uranium from the ore by acid leaching.

Narwapahar is another location of interest in this Belt. The Narwapahar deposit, lying in the middle of the Singhbhum Thrust Belt is the largest so far discovered in the country.

Barely 3 km. away from Jaduguda is Bhatin. This deposit is separated from the Jaduguda-Tirukocha mineralization by oblique Tirukocha fault which has horizontally displaced the lodes to the north-east by about 550 metres. Nickel and molybdenum zones are being demarcated in the mine as well as in the bore holes to ascertain their nature, extent and their available resources.

Other areas in the Singhbhum Thrust Belt which hold out promise are Keruadungri, Kanyaluka, Purandungri, and Bagjata.

Investigations all over India for the last 18 years have shown that deposits of consequence are confined to the Singhbhum Thrust Belt area. Though uranium mineralization here is consistently of low grade, it is so far the most important and richest uraniferous region in the country.

Apart from Bihar, two uranium deposits have been discovered near the city of Udaipur in Rajasthan. One at Umra and the other at Udaisagar, have been explored and partially developed. In the Umra deposit, uranium occurs in lenses of variable size, distributed fitfully along the shear zones. It is found to contain a number of colourful secondary uranium minerals.

The other deposit of Udaisagar is altogether low-grade and mineralization is in the form of stringers and specks of uraninite, chalcopyrite as well as some secondary uranium minerals.

The discovery of uranium in some parts of the Himalayas has opened a new field for exploration in a terrain which had generally been regarded as unfavourable for mineral deposits.

Some minor occurrence has also been detected in a coal seam in the Khasi and Jaintia Hills district of Assam State, and in certain granites in the States of Rajasthan, Andhra, Tamil Nadu and Bihar. But these are small and of low grade and thus not of much significance at present.

Thorium: India has a special interest in developing the use of thorium resources for power generation because she has the largest established reserves in the world.

Monazite, a source of thorium, is widely distributed in the granites, meta-sediments, and sedimentary rocks of Peninsular India, as well as along many river and stream courses. It is transported to the sea by the rivers where it is deposited along with other alluvial detritus and reworked from the sea bottom and redeposited by waves on the beaches. Rich deposits occur in parts of Kerala, and South Tamil Nadu coasts. Inland deposits of Ranchi district in Bihar and the adjacent plains of Purulia district in West Bengal contain significant reserves of monazite. Other areas on the sea-board are progressively being surveyed.

The heavy black sands of the seacoast of Kerala and Tamil Nadu are one of the foremost mineral assets of the country. These deposits, discovered in 1909, are rich also in minerals like ilmenite, monazite, sillimanite, rutile, zircon, and garnet. The two main deposits are at Chavara near Quilon in Kerala State and in Manavalakurichi in Tamil Nadu. Presently, only the sands occuring on the surface are being treated but in future, deep mining may be necessary to recover all the minerals.

Beryllium, Lithium & Zirconium: Surveys for beryl are continuing in the mica belts of Bihar, Rajasthan, Andhra Pradesh etc. and have also been extended to parts of Madhya Pradesh, Orissa and Tamil Nadu. New beryl bearing pegmatites have been discovered in Hazaribagh (Bihar), Ajmer (Rajasthan), Sarguja (Madhya

ALS IN INDIA

Pradesh), Coimbatore (Tamil Nadu), and Sambalpur, Dhenkanal and Cuttack districts of Orissa State. A new promising occurence of columbium-tantalum has been reported at Khairidih in the Hazaribagh district of Bihar.

Lepidolite: The chief ore of lithium, lepidolite occurs in some pegmatites in the well-known mica fields of India.

Zircon: India possesses considerable resources of zircon, the main source of zirconium. Zircon is associated with ilmenite and monazite in the heavy mineral sands of the coastal and inland placers.

The Rare Earths: The rare earths occur as phosphates in monazite which also contains appreciable quantities of thorium and small quantities of uranium. As has been stated, the largest deposits of monazite occur in Bihar Kerala and Tamil Nadu. The Kerala and Tamil Nadu deposits have been exploited since 1911, but the Bihar deposits, which were discovered more recently still wait to be exploited. Since 1911, the mineral sands of the west coast of South India have been processed to extract ilmenite. As the demand for rare earths and thorium grew, treatment of monazite for the extraction of its other components became economically attractive. A plant for extraction of rare earths has been operating at Alwaye since December 1952. The Indian Rare Earths Ltd., a Government company, is treating beach sands in a plant at Manavalakurichi, for the separation of monazite from the beach sand, and the monazite itself is treated in another plant situated at Alwaye for the separation of rare earths. The solid residue from the Alwaye Plant containing thorium and uranium is separated from rare earth solution and is sent to the Thorium Plant at Trombay for further treatment.

The Thorium Plant at Trombay, operated by the Indian Rare Earths Ltd., processes this residue to obtain thorium nitrate and uranium fluoride. Thorium nitrate is widely used in the gas mantle industry and the plant at Trombay has been meeting the demands of the industry not only in India but also abroad. Uranium fluoride is further processed at the Uranium Metal Plant at Trombay to obtain nuclear grade uranium metal (and lately, ceramic grade uranium oxide, etc.) while the Atomic Fuels Division of the Bhabha Atomic Research Centre meets the needs of both the CIRUS and the Zerlina reactors at Trombay. This Division in addition, is continuing development work for such fuels and cladding materials as are required for the country's nuclear power programme. It is at present fabricating the initial half charge of UO_2 fuel, jacketed in zircaloy tubes, for the first unit of the Rajasthan Atomic Power Project.

A Nuclear Fuel Complex is being set up at Hyderabad which will consist of (1) a Uranium Oxide Plant, which will produce ceramic quality reactor-grade uranium oxide, (2) a Zirconium Plant to process Indian zircon into nuclear grade zirconium oxide and zirconium sponge metal. The sponge will be converted into zirconium alloy tubing and shapes as required for fuel element sheathing and for other reactor core components (3) A Ceramic Fuel Fabrication Plant where the ceramic grade uranium oxide powder will be made into sintered pellets and loaded into zircaloy tubes by inert gas welding, which will then be assembled into fuel element bundles.

Pilot plant programmes on the production of nuclear grade zirconium oxide from Indian zircon, and its further conversion to zirconium sponge metal, arc-melting and extrusion of zirconium alloys, production of ceramic grade uranium oxide powder, and sintered uranium oxide pellets, are continuing at the Bhabha Atomic Research Centre, Trombay.

The Doctor and the Computer

(Continued from page 7)

encephalograph (or the EEG) an instrument that records "brain waves" of people. The brain, we all know, has a very large number of individual nerve cells—millions of millions, actually, all usually very busy. They work using chemical energy to generate electrical signals which they flash back and forth between one another, much like the circuits of a computer. The EEG machine, being very sensitive, measures the sum total of all this electrical activity from outside the skull—like a man trying to tape record all the conversations in a fish market or a fun fair, from a distance.

It would appear to be a hopeless task to try to make sense out of this mess and draw conclusions about specific malfunctions—as hopeless as listening to the noise from outside a huge workshop and trying to tell what might be wrong with what machine.

Understanding the Brain

There are complicated mathematical analyses that can be done on the record signal and useful conclusions on the patient's condition can be drawn on the basis of such analysis. The neurophysician, however, lacks both the mathematical background and time to do this. He generally makes only some simple measurements and, using his long experience, tries to draw meaningful conclusions by merely looking at these records. Computer analysis can lead to much more fruitful results. We are actually ourselves trying to establish a computer aided method to diagnose schizophrenia—or split-personality—using EEG records.

Computers are being used to understand the mystery of the human brain and intelligence by simulating—or imitating—intelligent human behaviour. They are being used to understand models of circulatory systems

(Continued on page 8)

The Doctor and The Computer

by Dr. P. V. S. Rao
Computer Division
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Bombay.

MOST of us have heard the Sanskrit adage equating the medical man with God Himself.

One could almost agree with this, particularly when one is sick and helpless—when a doctor is tending to him—as much with kindness, confidence and encouragement as with the actual medicine! The relation between a doctor and a patient is indeed a sacred one—even in law!

How would you react to the suggestion that the friendly family physician be replaced by a machine? A computer to feel your purse—I am sorry—pulse, listen to your heartbeat, prescribe a medicine and, perhaps, say a consoling word or two! Are doctors and patients getting concerned? Please don't! I don't really intend to talk about this. Such a possibility is never likely to materialise.

What I do wish to talk about is the use of computers in medicine — not to replace the friendly physician, but to help him.

How could a computer really help a doctor? For one thing, it could do his book-keeping for him, and make really sure that you and I paid his bills promptly and fully. Are there other ways?

Doctor - Patient Relationship

Let us examine the relationship between a doctor and his patient in all its aspects. The first is verbal communication between them. The doctor has to get information regarding what is wrong with the patient, ask him questions, encourage him to speak, and describe the nature of his trouble. How well a doctor can do this will determine, to a large extent, how well he can treat his patient. It is very important for the doctor, to establish rapport with his patient and build his self confidence and confidence in the doctor. One might say there is not much room for a computer here. No patient would really like to go through a lot of form-filling to help a machine diagnose his ailment and cure him. There are exceptions, however. It was found in the Mayo Clinic, for instance, that computerisation helps, even in this area, for some types of ailments. Patients undergoing psychological testing found it much easier to answer intensely personal questions during routine form-filling rather than while talking it over with a psychiatrist. This makes it easy for a computer to step in. It goes through the answers (which are suitably coded and fed in) and prints out a psychological evaluation for the benefit of the doctors. There are several advantages in this method: a lot of time is saved, the evaluation process is uniform and unbiased and, further, the attending physician need only be an intern, rather than an experienced psychiatrist.

Once the doctor knows about the symptoms, he has to decide, on the basis of this knowledge, as to what is the actual ailment. If however, the case is a rare and unusual one, he might want to refresh his memory — by looking up a text book, or falling back on his own previous experience of a similar case — or on the experience of his other colleagues. Here, a computer could really help by making available, at his finger tips all the upto-date information that exists with regard to a particular symptom, disease or drug.

The next step is diagnosis—giving a name to the ailment—and this is a *rather* critical step, you will all agree. You will remember the old time country doctors. Isn't your grandfather always praising him? He had only to feel your pulse and he would diagnose exactly what is wrong with you — we have all the respect for him, but we have to recognise that such a thing is clearly impossible in modern medicine. The main difficulty a doctor faces — after all, he is also human — is his inability to remember all the diseases that produce identical symptoms, and what tests to prescribe, to decide between them. In ophthalmology, for instance, there are nearly two thousand symptoms connected with a thousand illnesses of the cornea alone! A slide rule type of contraption was once built to make this task easier. It could match 82 symptoms and help the doctor select one out of 337 diseases as the most likely one; but even this is far too inadequate in modern times. A computer could definitely help. Programs have been written to make computers perform this function quite satisfactorily.

Studies are also being made of the actual methods doctors use for diagnosis — with the hope that these will help in writing better computer programs for this purpose.

Helping Doctors

If a machine can help in the diagnosis of a disease, it follows that it can also help in training doctors how best to do this, themselves. Let me tell you about a computer program that could do just this. The computer had available to it, complete information linking 359 symptoms to 74 diseases, and played a very educative game with its students. At the start of the game, the name of a disease (of an imaginary patient) and its most important symptom were loaded into the machine, unknown to the student. The machine then printed for the benefit of the student, a long

How would you react to the suggestion that the friendly family physician be replaced by a machine? A computer to feel your purse…er..pulse, listen to your heartbeat, prescribe medicine and perhaps say a consoling word or two?

Computers can be clerks, assistants, consultants, and even teachers to medical men. They have made, and are still making, huge inroads into medicine, medical practice and research.

list of all the possible diseases that could give rise to this one symptom. It was upto the student to ask a question regarding another symptom, in order to narrow down the list. If this was a relevant question, the computer answered yes or no, indicating the presence or absence of this symptom. It also printed a modified (shortened) list of diseases which have both symptoms alike. The student then asks a third question, about another symptom, leading to a further narrowing down of the range of diseases, and so on. The game ends when the list has been narrowed down to just one disease. The object is for the student to complete the game asking as few questions as possible, choosing thereby the most efficient way of diagnosing a disease. He learns to concentrate on these symptoms which are most helpful in discriminating between different diseases, symptoms that are most important.

Hospital Automation

Once a disease has been identified, one might suppose that treatment is comparatively straight forward. One has to contend, however, with hereditory, environmental, physiological and other considerations, which influence the final decision as to what treatment is to be prescribed. Age, previous history of the patient, his habits, activities, and attitudes all play a part. Even assuming that all these data are available, it is inconcievable that a doctor can weigh all these factors as well as a computer.

Another very interesting area of application for computers is in hospital automation. Some of you might have heard about using computers for running large factories and big industrial processes—oil refineries, steel rolling mills and so on. The ability of a computer to keep track of a large number of individual details and to take appropriate action, as specified, in any eventuality is the reason for its use in this field. For the same reason, a computer can also be used in hospitals. Imagine a hospital with a large number of patients suffering from a broad spectrum of ailments and requiring varying degrees of medical care and different types of medication and diet. A large fleet of nurses, interns, and physicians would normally be required to keep track of and organize all these activities. Imagine a computer entrusted with this responsibility. It can sense the temperature, blood pressure, respiratory rate, and any other parameters of any number of patients as frequently as required, automatically, and record them systematically. In fact, it can do much more. Imagine a patient whose temperature the doctor is worried about. The doctor has merely to set a limit and "tell" the computer. If the temperature exceeds that limit, the computer will automatically tell the doctor, or if so instructed before hand, change medication. It will, if instructed appropriately, remind the attending nurse whenever medication falls due, exactly in time.

Suppose for a particular case, the doctor prescribes an overdose of say, aspirin. The computer even comes up with a gentle reminder and asks him to reconfirm. At medicine time it tells the nurse the prescribed dosage and also that the doctor ordered an overdose. The nurse is thus reassured that no mistake is being made.

During a complicated operation, it can keep track of a very large number of measurements being done on the patient, analyse them and send a warning in case of abnormality long before a human can notice it.

Since it is anyway dabbling with medicines and treatments, it can very well keep inventory, and generate purchase orders whenever stocks run low. Preparation of diet and catering administration can similarly be organised.

It can keep patients' records at the time of admission—covering their previous medical history, peculiarities such as allergies or adverse reactions to specific drugs, family background and ever so many other details. It can help the doctor by cross checking his proposed treatment against all this background information and warn him whenever there is an inconsistancy.

Using all this information, it can deliver statistical analysis of any type desired, regarding specific ailments, localities, or medicines used.

All this adds to quite an impressive list of chores. To round it off, we might entrust it with one more responsibility ... billing the patient for all the services he has received.

As An Analyst

Another vast area where computers can really be used is in public health. Compilation of physiological data, statistical analysis and correlation, studies and predictions, of the spread of epidemics and other diseases, evaluation of the efficacy of preventive measures that might be taken etc.

As an analyst, it can help the physician. Some of the tests that a modern specialist can prescribe using sophisticated instruments are so complicated that it is practically impossible for him to fully interpret the results all by himself. The electrocardiogram and the electro-encephalogram are very good examples. Let us look for a little while at the latter!

As an analyst, the computer can help the physician. Take an electro-

(Continued on page 5)

In medical science, as in any field, the degree to which a machine can intelligently be used and exploited is up to Man. If he depends entirely on these machines to do his dirty work and all his intelligent work, the doctor can get stuck in a pool of stagnation.

The Medical Computer

(Continued from page 5)

to gain an insight into the secrets of evolution and ecological balance between species—to do blood counts of leucocytes and diagnose ailments such as binucleate hymphocytics and even so many other spectacular things. Computers, we have seen, can be clerks, assistants, consultants and even teachers to medical men. We have to recognise that computers have made and are still making huge inroads into medicine, medical practice and research. They will continue to do so. What does this mean? The prophets of doom might lament that this is yet another sacred portal that is being polluted by the iron and steel of these machines — yet another instance of the increasing mastery of machine over Man — yet another portent of his degradation and downfall into a state of utter helplessness and complete dependence on machines. Is all this true? The answer is — No. In medical science, as in any field, the degree to which such a machine can intelligently be used and exploited is up to Man. If he depends entirely on these machines to do all his dirty work and all his intelligent work, the doctor can get stuck in a pool of stagnation. It is upto him to keep one step ahead — to sharpen his initiative, enthusiasm, experience and skill using the extra power that computers put at his disposal. Will he rise to the challenge? I am sure he will. (*Courtesy, AIR Bombay*). ●

View of gallery of hydraulic control rod drives at the Tarapur Atomic Power Station

Fuel Loaded Into Oyster Creek Station

FUEL loading into the Oyster Creek Nuclear Generating Station began early in April, marking the beginning of a series of tests preliminary to commercial operation around mid-year. The 640-MWe BWR, the largest commercial plant fueled to date, was built by General Electric on a turnkey basis. After fueling is completed and criticality is achieved, the plant will be tested at zero power for several weeks followed by about two months of power-range checks. Full power tests will then precede turnover of the plant to Jersey Central Power and Light for commercial power generation.

Completion of Oyster Creek has been delayed for a number of reasons including discovery in 1967 of minute blemishes on the surface of some furnace-sensitized stainless-steel reactor components. An exhaustive repair programme has been completed to insure the system now meets the prescribed quality standards.

• • •

Centrifuged Viruses Fight Tree Moth

THE US AEC's ultra high speed zonal centrifuge, which has already been used in the production of influenza vaccine, has now found another non-nuclear use. A virus that is species specific to the tussock moth, a destroyer of Douglas fir trees, has been produced in the centrifuge, and a single day's output is sufficient to spray 1,000 acres of trees. Similar programmes are being tested for use against other pests such as the gypsy moth, the bollworm, and the European pine sawfly. (*Nuclear News, May, 1969*). ●

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Dr. Sarabhai's Press Conference

'Nuclear Power Is Advantageous In The Long Run'

QUESTIONS on the Tarapur Atomic Power Station, the relevance of nuclear energy in India's power development programme, plans and strategy of the Atomic Energy Commission in this regard, and the Fast Breeder Reactor programme, came up for discussions at a get-together of Bombay newsmen with the Chairman of the Atomic Energy Commission, Dr. Vikram A. Sarabhai on May 22.

At the beginning, Dr. Sarabhai sought to clarify some points on Tarapur. He said that the intermittant flow of power from the Station appeared to have created an impression in the public mind that some things were not right with it. He explained that the Station was essentially being operated for full-scale testing during which period its power output was being supplied in the region on an "as available, when available" basis as had been made clear in the beginning. He emphasised that thorough testing was essential before commissioning as removal of defects which might appear afterwards would be time consuming and costly because many parts of the plant would be inaccessible due to radioactivity. Short-cuts in the case of nuclear power plants especially are not desirable as they could prove disastrous. Dr. Sarabhai stressed that it was in the best interests of the nation that such a project should be started properly. The Atomic Energy Commission would make no compromise whatsoever on safety, he stated. The Chairman confirmed that testing operations

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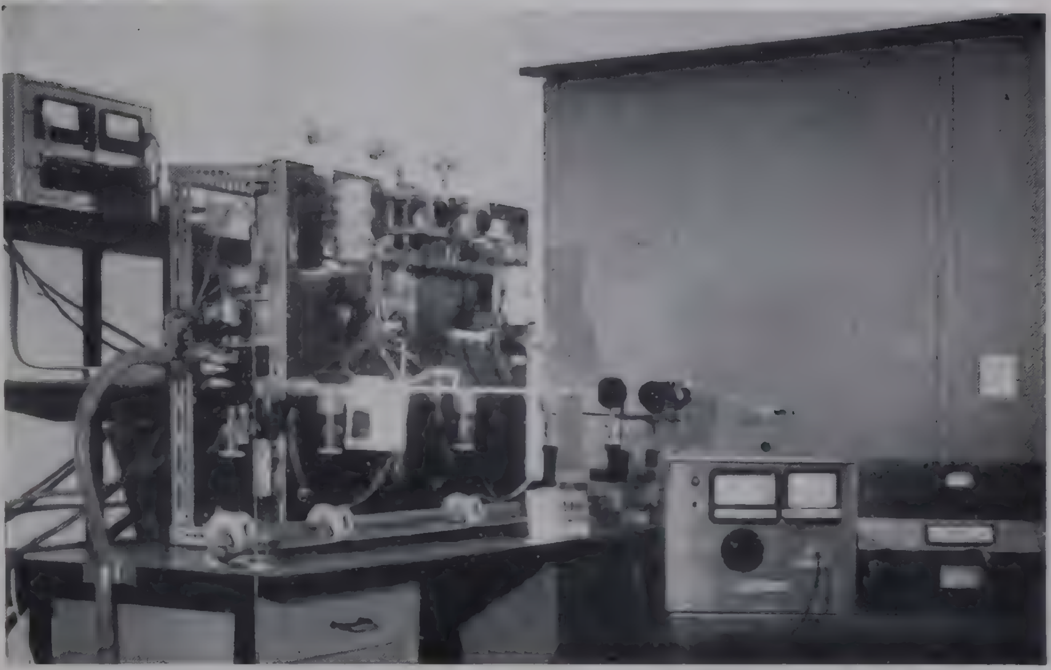

The BARC-developed Helium-Neon laser with the gas filling system.

BARC Develops He-Ne Laser

THE Electronics Division of the Bhabha Atomic Research Centre, Trombay, has successfully designed, constructed and operated a Helium-Neon gas laser.

The laser generates a coherent and highly directional infra-red beam of wavelength 11,523 Å (1.1523 microns). The maximum continuous power in the beam is about 1 milliwatt. This beam is invisible to an unaided eye but may be viewed with an infra-red image convertor or detected by photo sensitive devices.

This laser consists of a glass discharge tube filled with a mixture of Helium and Neon and kept between two multilayer dielectric mirrors which have high reflectivity. On passing a current through the discharge tube, the neon atoms are excited to higher energy states from where they decay to lower energy states by emitting light. The mirrors reflect this light back into the tube where it stimulates other atoms also to emit light, thus building up the intensity of light within the tube. The slight transparency of the mirrors allows a small fraction of this light to come out as a highly directional and coherent beam. By using different sets of mirrors the laser can be made to generate a light beam at one of the three wavelengths—11,523 Å or 33,400 Å which are in the infra-red, or 6328 Å which is in the visible region of the spectrum. Although the power in the beam is low, due to its coherence it can be focussed to a very small spot giving intense illumination over a small area.

For a He-Ne laser, the reflectivity of the mirrors should be very high, typically about 99.5%. Metal coated mirrors which are commonly used in other areas of optics are unsuitable as the maximum reflectivity that they have is only 96%. The solution is to use a multilayer dielectric mirror. The reflecting surface in such a mir-

(Continued on page 4)

'Increasing Emphasis on Nuclear Power Throughout the World'

(*Continued from page* 1)

were continuing smoothly and no difficulties had been experienced. Very soon, Tarapur would be feeding power into the national grid on a commercial basis. The power generated would be worth approximately Rs. 14 crores a year.

Giving the breakdown of the capital cost of the Project as estimated from time to time, the Chairman detailed the factors responsible for its increase. In November 1962, the original estimate was Rs. 48.5 crores. In May 1966, due to increase in customs duty primarily, the cost went up to Rs. 55 crores. In early 1968, due to the effects of devaluation, it became Rs. 65 crores. The present figure is Rs. 65.20 crores which includes cost of inerting, escalation and changes. The increase in cost of power from Tarapur from the original estimate of 3.22 paise/kwh to the present one of 4.73 paise/kwh is again due to increase in customs duty on plant and fuel, effects of devaluation on plant and fuel costs, insurance, and contingencies not previously included. The selling price of power would now be 5.61 paise/kwh.

Economics of Nuclear Power

Making a comparison between a Candu-type reactor (like the ones at the Rajasthan Atomic Power Station) and a reactor using enriched uranium (as those at Tarapur), Dr. Sarabhai said that in the case of the former, the capital cost would be higher than that of a reactor using enriched uranium, but one should realise and appreciate that in the Candu-type reactor, natural uranium is used, not enriched uranium, which has to be imported. Comparing the fuel costs, he said that while it came to 1.63 P. per kwh in the case of a Tarapur-type reactor, it worked out to only 0.34 P. per kwh for the Candu-type reactor.

Coming to the economics of nuclear power stations vis-a-vis conventional power stations, he observed that larger the nuclear power station, the lesser would be the cost of power. While the total power cost per kwh at the Tarapur and Rajasthan Stations would be in the region of 4.7 paise, the power generated at a thermal station in the same region would work out to 6.64 paise per/kwh. After detailing the background, Dr. Sarabhai observed that the present was a most crucial stage for the nuclear power programme. If at this stage the country faltered and adopted a stop-go policy in this regard, it would not be able to achieve the goal, namely, a target of 3000 MW by the end of the Seventies which Dr. Bhabha had visualised. The original schedule was to generate 1000 MW by the end of 1970 from the three power stations now under construction. The slight lag in keeping to the schedule would be compensated by accelerating the tempo of work in future programmes. It is significant that future reactors would be built without any foreign help, he stated.

Not Inexpensive

In reply to a question, Dr. Sarabhai said that the atomic power programme was not inexpensive but, considering the advantages and profits in the long run, the investment was worth its value.

There was an ever increasing emphasis on nuclear power throughout the world, he continued. Towards the end of 1968 there were 81 nuclear power reactors in 18 countries, generating a total power of about 11000 MW. India could fulfil its plans of raising its total output of nuclear power to 3000 MW by adding another 2000 MW during the Seventies. The Chairman emphasised that development of nuclear power did not mean that hydro and thermal power generation should be ignored. On the contrary, all the three sources of power should be fully utilized to derive the maximum beneficial results.

French Know-How

Touching the AEC's Fast Breeder Programme, the Chairman explained that the technology in this case being a most advanced one, very huge investments were being made throughout the world on its commercial utilization. In this connection, he referred to the plants coming up in the USSR, USA, UK, France, etc. and observed that full benefits would be realised when a fast breeder reactor of 1000 MW installed capacity was developed.

On the question of borrowing know-how from foreign countries, he said that there was no need to feel a sense of inferiority as it was much better to take lessons from countries advanced in a particular technology than to start from scratch and do what others had already done. He added that the AEC was collaborating with the French Government which had invested as much as Rs. 200 crores so far on the fast breeder programme. ●

Fibre Glass In Rohini Rockets

A fibre glass filament wound rocket motor was successfully flight-tested at Thumba on June 6 as part of the Rohini programme of the Space Science and Technology Centre. Fibre glass, which combines qualities of high strength with light weight, is used for making motor cases in most advanced rockets. The body of the rocket motor was fabricated by the Development Group at the Thumba Equatorial Rocket Launching Station. A new high performance propellant developed at the Space Science and Technology Centre was used in the test. Though the first rocket was only 125 mm in diameter, the test has established the feasibility of using indigenously developed fibre glass technology for the bigger motors which are required for the Indian satellite launching programme.

PERSPECTIVES IN RADIATION MICROBIOLOGY*

by

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I have set upon myself the task of highlighting some of the great contributions that microbiology as a science and radiation as a research tool have together made to widen the frontiers of our knowledge on fundamental mechanisms in life processes. I shall also briefly review some of the successful applications of radiation microbiology, including the potentials it has in helping to meet man's food needs.

Microorganisms could be widely diverse—some unicellular and some multicellular, some truly plants and some animals—and are grouped together only because of their size. They are ubiquitous and, in spite of their small size, produce extensive changes in their environment. They also have profound influence on life on earth. Though their existence has been known to man for over 300 years, the foundations for their scientific study may be said to have been laid by the elegant observations of the great French scientist, Louis Pasteur, almost 100 years ago. As this science has continued its steady progress, previous misconceptions concerning processes such as decay, fermentation, reproduction, growth, health and disease have been replaced by highly significant concepts that have revolutionised our approaches to the biological sciences, besides contributing directly as well as indirectly to the betterment of human welfare.

Biogeochemical Action

Among the innumerable activities of microorganisms that contribute to sustaining higher forms of life on earth are their biogeochemical action in weathering and soil formation, decomposition of organic remains, primary production of organic matter, deposition of economically important substances such as oil and coal and so forth. There is also their specific symbiotic action in the digestive processes of ruminants and other herbivores, in supplying essential nutrients to the human organism and in biological nitrogen fixation. In addition, microorganisms have been harnessed in converting inexpensive raw materials and industrial wastes into economically valuable compounds such as life-saving antibiotics, vitamins, amino acids, steroids, organic acids, industrial solvents, chemical intermediates, fermented beverages and foods, flavoring agents, growth stimulants, enzymes and a host of others.

Same Enzyme Systems

Quite apart from their exploitation for such manifold practical benefits, study of microorganisms has contributed enormously to the broadening of man's understanding of life processes.

Microbes provide excellent systems for the study of many fundamental biological problems. They can be manipulated more readily than higher organisms and are adaptable to various experimental situations. A simple test-tube or flask can be converted into a precise, reproducible and meaningful ecosystem. Moreover, statistically significant numbers can be handled readily and each member of the homogenous population can be considered a discrete unit, independent of the other members. Extensive biochemical studies have revealed that microorganisms, with few exceptions, have the same enzyme systems and metabolic pathways as the cells of higher organisms.

New Insights

Studies on microorganisms have provided a tremendous store of fundamental knowledge as witnessed by the spectacular achievements in the present era. New insights into microbial physiology and metabolism have catalysed studies on microbial genetics and gene-controlled regulatory mechanisms. The gene, which until recent times, had a mystical aura around it, has now been shown to be a chemical entity. Microorganisms have been immensely helpful in unravelling mechanisms of information transfer in terms of DNA replication, transcription and translation and the regulatory processes governing them.

In addition to these discoveries which have thrown light upon some of the most obscure problems of biology, great advances in the field of medicine have also been made possible by knowledge gained from microbes.

At about the same time that studies on microorganisms were beginning to be vigorously pursued, another potent research tool for probing the secrets of life became available in the form of ionising radiations. It was soon realised that it presented a new kind of dissecting instrument that is destructive and selective, localisable or universal, threatening and yet promising.

The successful applications of radiation for therapeutic and diagnostic purposes in medicine are only too well known.

Two-edged Sword

It has been known since the early 1900's, ironically enough through the tragic personal experience of several of the pioneering investigators, that ionising radiation can interact with biological systems to produce profound changes. While only the harmful effects appeared apparent in the beginning, it soon became evident that ionising radiation was a two-edged sword with potential promise in many directions. As we know today, developments since then have shown that the biological effects of radiation have indeed been turned decisively to man's advantage. The new science of radiobiology which has thus emerged has contributed greatly towards understanding some of the complexities of cell function and the relationship of cell structure to such functions.

(*Continued on page* 5)

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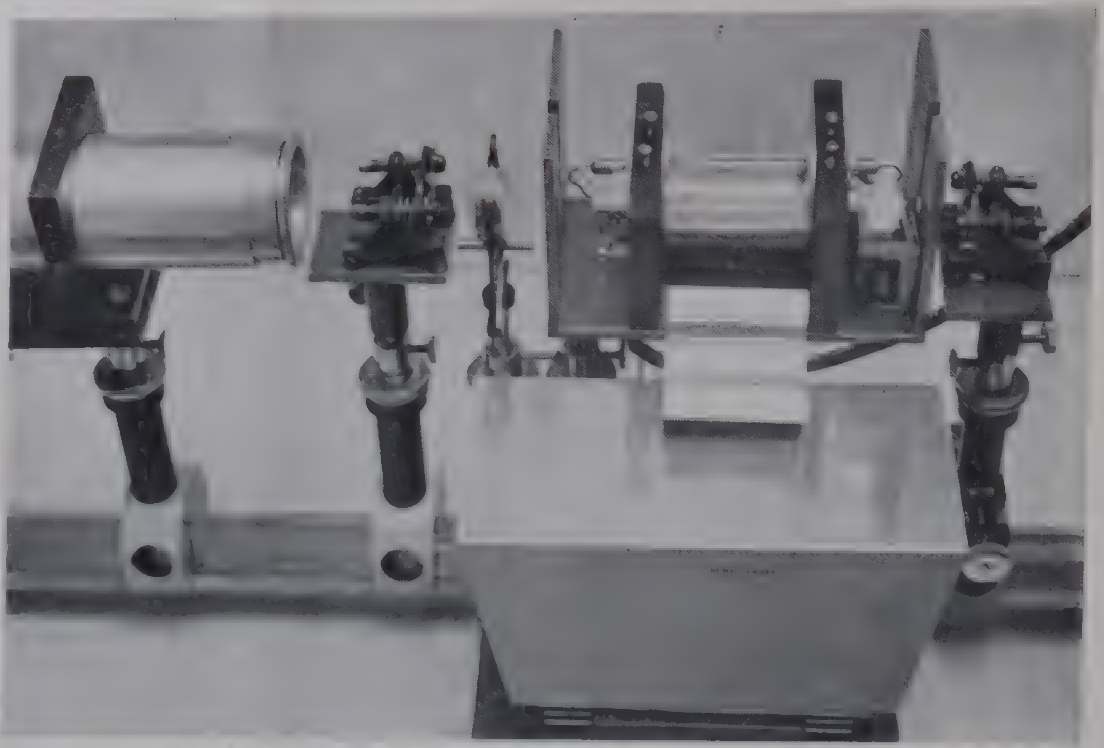
*Excerpt from the Valedictory Address at the IAEA/DAE International Course in Radiation Microbiology at the Bhabha Atomic Research Centre, Trombay, on May 15, 1969.

Useful Tool for Research, Communications and

(*Continued from page* 1)

ror consists of several alternate layers of two dielectrics such as zinc sulphide and magnesium fluoride. The optical thickness of each layer is only one-fourth the wavelength at which high reflectivity is desired. The layers are vacuum deposited, their thickness being monitored during the process. Mirrors with 17 layers give reflectivity higher than 99.5%. The technique of depositing these multilayer coatings has been developed in Trombay and mirrors for various lasers are regularly being made. Also, all the components for the He-Ne laser, incidentally, are now fabricated in Trombay.

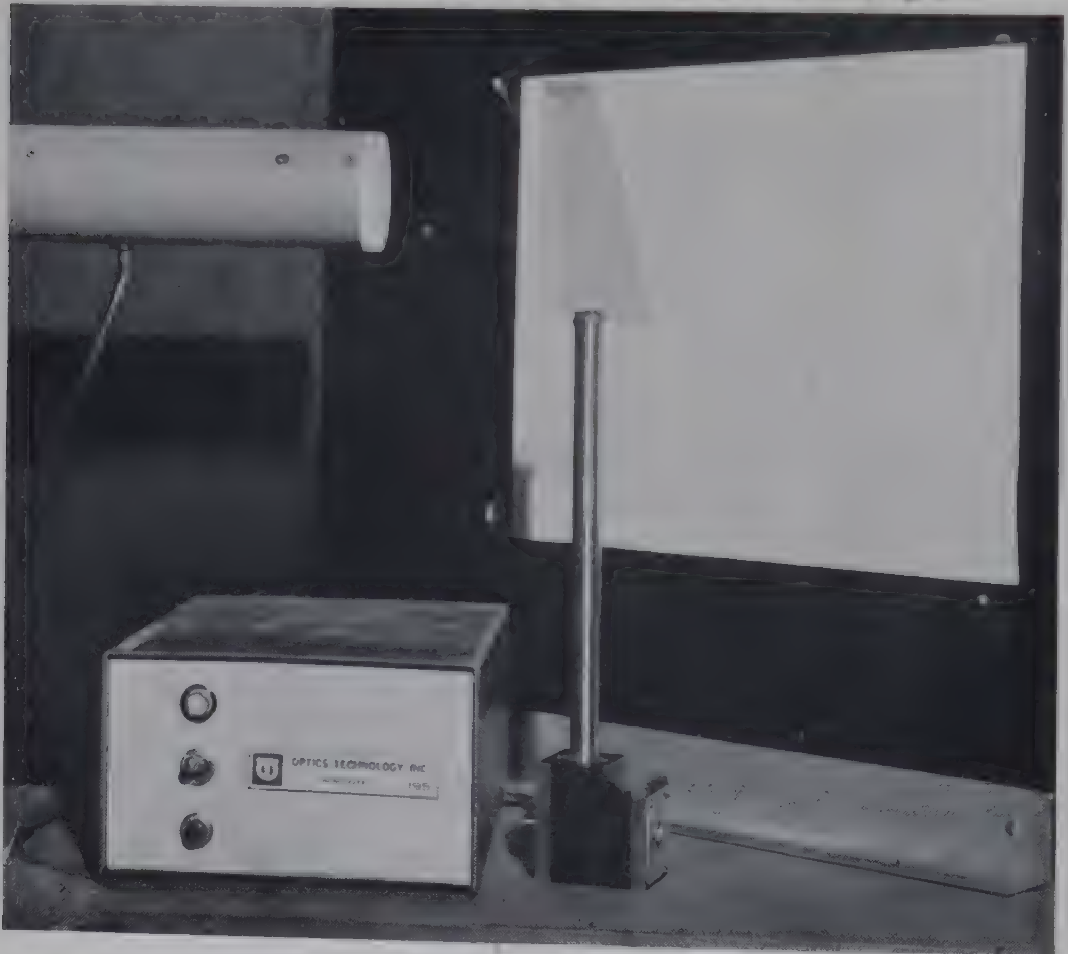


Ruby laser set-up (with upper half of the cavity open)

Useful for Research

The ability of the He-Ne laser to provide intense illumination over small areas is very useful for research in many fields such as Raman spectroscopy and non-linear optics. The directional nature of the beam makes this laser attractive for optical communication and optical radar and makes it also an invaluable aid in aligning complex optical instruments, large mechanical systems etc. It is a handy instrument for university laboratories for demonstrating the fundamental properties of light such as diffraction etc.

Set-up for image construction, using a hologram and a He-Ne laser. The hologram is in the middle and the He-Ne laser at left. The image is thrown on the screen on the right.



Another interesting and important application of the laser is in the field of holography, also known as "Lensless photography", and optical computation. A hologram is a record of the interference between a laser beam and light scattered from an object illuminated by the laser. For making a good hologram it is essential that the light is coherent. When a hologram is illuminated with a laser beam, it produces a three-dimensional image of the object. An interesting property of the hologram is that even a small piece of it gives a complete image of the object. Also, on one photographic plate it is possible to store many holograms. The hologram can thus store a very large amount of information on a small photographic plate.

Communication Link

The laser group at Trombay started developing the Gallium Arsenide (GaAs) Semiconductor laser in July 1964. The first GaAs laser was fabricated in May 1965. Since then a number of these lasers have been made with improved characteristics. One of these was used for a communication link between the Bhabha

Atomic Research Centre and the Tata Institute of Fundamental Research, a distance of 20 kms, in December 1965 (Refer *Nuclear India* Vol. 4, No. 8, April 1966). At present the group is developing several types of laser *e.g.* GaAs Laser, Helium-Neon Laser, Ruby Laser, Neodymium doped glass Laser, Carbon dioxide Laser, Argon ion Laser, and Liquid Laser. Of these, the first four have already been successfully operated. The Ruby and Neodymium doped glass lasers are pulsed lasers which generate intense beams of light in short bursts. The principle of operation of these lasers is similar to the Helium-Neon Laser. In these, the active element—either a ruby crystal or Neodymium doped glass rod—is placed between two reflecting mirrors and excitation is provided by a Xenon flash lamp. A Q-switched ruby laser constructed at Trombay generates a short pulse of intense coherent beam the power of which exceeds several megawatts and the pulse duration is shorter than 25 nano seconds (25 x 10^{-9} secs). Several applications of these are being investigated at Trombay. One of the applications is in the treatment of detached retina of the eye. The ruby laser, which is used for this purpose, is being further developed. Also under development is an optical radar using a Q-switched ruby laser. Other possible uses of these lasers are in micro machining, study of non-linear optical properties of materials, production of high temperature plasma etc.

Recently scientists at the Lebdev Institute, Moscow used one such laser, delivering 2 x 10^{12} watts in a pulse of duration 10^{-12} seconds, to create a plasma of lithium deuteride, the temperature of which was high enough to initiate thermo-nuclear fusion. Such high power lasers are likely to play a very significant role in the investigation of the fundamental nature of matter. ●

Real image of various objects, thrown on the screen when the hologram (which is on top left) is illuminated with the laser beam.

Radiation Microbiology

(*Continued from page 3*)

Progress in the elucidation of life processes has resulted largely from studies on stress effects. Thus, the role of a vitamin or a hormone is discerned from metabolic deviations caused by its deficiency in the organism being studied. Environmental stress effects could likewise be useful. By upsetting the state of equilibrium of cellular processes, they provide insight into mechanisms of derangement, repair and regulation. In this respect, ionising radiations have been exploited much more than perhaps any other agent. Several major advances in biochemistry have been possible mainly as a result of investigations into the nature of radiation-induced metabolic disturbances in micro-organisms. Cellular repair processes and regulatory mechanisms have been unravelled not so much by study of organisms under normal homeostasis as of those in which metabolic processes had been interfered with by irradiation. Cell renewal systems are readily perturbed by ionising radiation and provide useful prototypes for study of the continuous interplay between proliferative and differentiative processes. Thus, studies on the effects of ionising radiation on phage alpha-DNA transcription both *in vivo* and *in vitro* have led to a better understanding of some aspects of template-enzyme interaction.

New Era

Without the use of radiation to increase the spontaneous rate of mutation, many productive genetic studies would not have been possible. When Müller showed in 1927 that ionising radiations could induce mutations in *Drosophila*, methods emerged for studying spontaneous and induced gene and chromosome mutations. A new era began in experimental genetics and cytogenetics which made possible deductions about the nature of their essential structures. Mutations which radiation produces in micro-organisms like *E. coli* and *Neurospora* have been of particular interest for

(*Continued on page 6*)

Use of Radiation Offers Greatest Hope for

(*Continued from page* 5)

the information they have provided on gene-enzyme relationship.

I would like to digress a little and make a point here. So rewarding has been the experience with studies on radiation microbiology that concurrent applications have been made possible in higher organisms with resulting feedbacks of information and knowledge. I may mention some illustrative examples of achievements in cell biology made possible through study of radiation effects.

Study of radiation effects on the metabolic events in normal tissue cells are already helping us to understand neoplastic cell populations and we may soon be in a much better position in our attempts to control cancerous growth.

Studies of the type of abnormalities produced by irradiation of embryos have demonstrated the developmental time sequence during normal organogenesis.

Electron microscopic and x-ray diffraction studies using radiations as probes have helped us learn much about the molecular structure and dimensions of such biological macromolecules as proteins, nucleic acids, viruses and related structures.

Light on Ageing

Another consequence of radiation effects on organisms has been to shed some light on the ageing process. By combining studies of late effects of radiation with those of natural ageing, it has been possible to show that the two phenomena have a great deal in common; this has resulted in the development of the somatic mutation theory of ageing. According to this theory, ageing is believed to involve progressive loss of functional and adaptive powers as a cumulative result of somatic mutations.

Studies on the origin of life also owe their success to the application of radiation. Thus, it is believed from simulated irradiation studies that, under primitive earth conditions, molecules of biological significance were formed by the action of ionising or ultraviolet radiation.

Perhaps the most widespread and unique application of radiation is in the use of radionuclides as tracers in research, medicine and industry.

There are many reasons for believing that radiation injury in higher organisms, manifesting in a variety of metabolic disturbances, derives chiefly from the damage which individual cells sustain. It has been the attempt of biochemists in this field to understand this injury in terms of discrete and specific events involving particular molecules that occur in the cell. From this point of view, fundamental information about the effects of radiation has been sought from studies with isolated cell cultures. Radiation responses in single cells can be assessed *in vitro* in a way that is virtually impossible *in vivo*. Since the primary events resulting from radiation exposure are the same, whether *in vitro* or *in vivo*, our understanding of the responses of single cells in culture provides an important base for the interpretation of the *in vivo* response of cells, of tissues and of whole organisms. Bacteria and bacterial viruses are comparatively easy to study and analyse at both the genetic and molecular levels and consequently have been widely used. There is good evidence that mechanisms described for bacteria can be extrapolated to eukaryotic cells.

Major Forward Steps

Microorganisms have been particularly useful in studies on radiation sensitivity since one can investigate populations of cells of different ploidys or of various mutant types to elucidate metabolic factors controlling radiosensitivity. It has been suggested that cells containing many mitochondria in the cytoplasm are more radioresistant than those with few mitochondria. Since mitochondria are the chief site of oxidative phosphorylation in the cell, presence of many such sites may be important in repairing damage caused by radiation. These possibilities can be experimentally probed with yeast cells grown in the presence or absence of oxygen or with the respiration-deficient 'petite' mutants.

Radiation studies with bacteria and viruses represent major forward steps toward an understanding, at the molecular level, of the mechanisms of inactivation, mutagenesis and recovery after exposure to radiation.

Some exciting developments have emerged in recent years from the multidisciplinary approach to radiation microbiology with the realisation that the observable radiation damage is in effect the net balance of the initial lesions minus the repaired ones. Isolation of radiation-resistant and —sensitive strains has provided some insights into the genetic control of radiation damage. Extensive research is currently in progress to elucidate the fundamental mechanisms responsible for repair, since control of its acceleration or inhibition has important implications for exploiting and extending the beneficial application of radiations in the life sciences, notably radiotherapy, and in minimising the hazards in nuclear industry and space travel.

Repair Processes

Current concepts in radiation microbiology implicate DNA as the site of the primary lesion which leads to loss of capacity for indefinite proliferation and it is thought that the efficiency with which a cell can repair this damage largely determines radiosensitivity. The repair may involve excision and degradation of the damaged zones followed by repolymerisation and rejoining of DNA material. The repaired DNA is then capable of normal replication and the cell maintains its reproductive integrity. In such repair processes, the sequential action of several enzymes such as exonuclease DNA polymerase and polynucleotide ligase are believed to be involved.

Even though we know little about the intimate details of repair processes, it is clear that these are not limited to radiation induced changes in DNA but that they may have a

Economic Improvement

necessary function in normal growth as well as in repair of a variety of defects in DNA caused by physical or chemical insults.

The concept of repair has also led to the development of the 'mis-repair' hypothesis of chromosomal aberrations according to which aberrations result from an error in the cell's overhauling system as a consequence of which there is cross polymerisation involving two different lesions. Accordingly, no true exchange aberration can be formed in the absence of repair processes.

Of Economic Importance

There has indeed been a vast amount of knowledge gained from studies on the effects of ionising energy on microbes and these fundamental data are very pertinent to several practical applications.

Radiations can and have produced mutants of great economic importance. Through radiation induced mutations, we can broaden the total phenotypic spectrum of microorganisms so that new commercially available strains of microbes with undreamed of synthetic capabilities will result. The mutational approach to obtaining industrially important strains offers an endless and fascinating possibility. Greater use could also be made of radiation-induced genetic blocks to unmask useful but minor metabolic sequences of the cell.

The ability of ionising radiations, at certain doses, to kill microorganisms has also been used to advantage in producing vaccines of valuable immunising power as well as antigens. The immunising and antigenic properties of such products compare favourably with those obtained by the use of normal physical and chemical bactericides.

Food Preservation

A field of radiation microbiology which offers the greatest hope for the economic improvement especially of the developing nations of the world and which is bound to assume a major role in the coming years is the use of radiation in food preservation.

The potential that ionising energy offers for food preservation was envisaged as early as 1896 in the first publication on the effects of radiation on microorganisms by Minsch. It is aptly entitled, "On the question of the effect of Roentgen rays on bacteria and the possibility of their eventual application." The first patent for the use of high energy radiation for processing of foods was issued in France in 1929.

With few exceptions, food would remain edible indefinitely if kept free from microorganisms or if these were prevented from multiplying. The ability of ionising radiations to destroy microorganisms forms the basis for stabilisation of perishable foods, free from the objectionable effects of several of the commercially practised preservation processes. For, ionising radiations have a lethal effect, without causing any appreciable rise in the temperature of food irradiated, on microorganisms, parasites and insect pests. Preservation of foods through ionising energy could introduce a new dimension and flexibility into processing, transport, storage and marketing of foods, with major economic benefits.

Important Aspect

The principal objectives of the use of ionising radiation in food preservation are: (i) to retard spoilage by reducing the populations of spoilage microorganisms, (ii) to kill or control insect population, (iii) to control physiological processes such as ripening and sprouting, and (iv) to kill pathogenic organisms and parasites. It has been established that radiation treatment can be used to accomplish these objectives to varying degrees depending on the radiation dose employed and according to the degree of extension in shelf-life desired.

An important aspect for study in the application of irradiation procedures for food preservation will relate to the effects on nutritive value and on possible induction of toxic or carcinogenic substances or of radioactive nuclides. It has been extensively demonstrated in experiments with rats, mice, dogs, pigs and monkeys and with a wide variety of irradiated foods that they are safe for human consumption and are at least as nutritive as foods that have been thermally or otherwise processed by conventional methods. Experience, for over six years, with composite diets, irradiated at 2.5 Mrads, has established the comparative safety of such rations for laboratory animals in multi-generation tests. Food irradiation should, therefore, be considered as a process or a unit operation in food engineering practice, where testing programmes for new items or new procedures should be based so as to make reasonable extrapolations possible.

Symposium at BARC

A symposium on "Radiations and Radio-mimetic Substances in Mutation Breeding" is being organised by the Food and Agriculture Committee of the Department of Atomic Energy at the Bhabha Atomic Research Centre, Trombay, Bombay-85, India, during October 1969. The last date for sending the abstracts for the contributed papers is July 31, 1969. The abstracts should be sent to Shri N. S. Rao, Biology Division, Bhabha Atomic Research Centre, Trombay, Bombay-85, India.

No process, not even the ones widely in commercial use today, is totally safe or satisfactory unless adopted under specified standard conditions. In the evaluation of a processing technology, developing specific procedures would obviously be conditioned by regional and geographic factors like availability of raw materials, their seasonal distribution and other local problems and practices. Final account must always be taken of the benefits which a process confers as against any possible risks that might be involved in its adoption. It seems to me that food irradiation could be the most exciting and promising aspect of applied radiation microbiology — one that can best demonstrate the peaceful applications of atomic energy to the economic improvement of mankind. ●

The Changing Face of Kalpakkam

By P. K. Nagarajan

Madras Atomic Power Project. Road bridge under construction across the backwaters linking Edaiyur and Kalpakkam. The bridge will link the fast reactor and pulsed reactor sites.

ABOUT fifty kilometres off Madras city lies Chingleput, a district headquarter in Tamil Nadu. Some thirty kilometres away from Chingleput, on the coast, are clusters of small fishing villages like Edaiyur, Sadurangapattinam and Kalpakkam. Three years back, the coastline from Edaiyur to Pudupattinam, on the estuary of the Palar River, was just a vast stretch of sand, broken here and there by a stray palmyra or a casurina tree and an occasional cluster of fishermen's huts. On a hot midday, except for some catamarans on the horizon or a solitary bare-chested fisherman bringing in his catch, one hardly saw any sign of life along the sleepy coast. Today, an entirely different scene confronts a visitor to the area. The once desolate stretch of sand is now bustling with activity with hundreds of men and women, and an assortment of machinery engaged on a very modern enterprise: the building of India's third atomic power station.

The Kalpakkam atomic power plant will be of the Candu type using natural uranium as fuel and heavy water as moderator, much like the ones coming up at Rana Pratap Sagar in the State of Rajasthan. A significant aspect of this Station is that it will be built entirely by Indian engineers and scientists, making maximum use of indigenous material. When completed, in 1973, this Station will feed 200 MWe to the State.

Slightly north of Kalpakkam will be a fast breeder test reactor, forerunner of future fast breeder power reactors in the country.

A road bridge is under construction across the backwaters at Edaiyur to link up the coast. On the northern side of this bridge is the site for building a pulsed reactor, forming part of a Reactor Research Centre. In course of time, it will help in connecting the coastline by an unbroken road, with Madras city.

A modern township has risen up as part of the project. A housing colony accommodates some 500 families of men and women who are helping in introducing atomic power in the South.

Two Isotopes of Element 104 Discovered

IT was announced on April 16 that the Berkeley nuclear physicists have discovered two isotopes of element 104, namely 104-257 and 104-259. The team was led by A. Ghiorso who has been involved in the discovery at Berkeley of nine heavy elements from 95 (americium) to 103 (lawrencium).

Observation of the 104 was first reported by Dubna scientists, led by G. N. Flerov, in 1964 (the particular isotope they reported, 104-260, was not seen in the Berkeley experiments) They christened the element Kurchatovium. It has particular significance, not only as the heaviest element identified with certainty to date, but also as the first 'transactinide' element. It is the first element beyond the actinide transition series which ends with 103.

The identification of elements heavier than uranium began at Berkeley in 1940 with the discovery of neptunium (element 93). Within a surprisingly short time, many of them have proved to have practical applications as well as purely scientific interest — plutonium as reactor fuel and nuclear explosive, plutonium-238 as a heat source for auxiliary power supplies in space exploration, americium-241 as a gamma ray source for monitoring industrial processes, californium-252 as a neutron source with applications in medicine and in geological exploration on earth and in space. *(CERN Courier, May 1969.)*●

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Tarapur Acquires A New Meaning

TIME seems to stand still in the little west coast village of Tarapur, about 100 km. north of Bombay. But for the obtruding telegraph poles along its two, narrow rubble streets and the few scattered brick and concrete structures, the palm fringed little village could well belong to any period in India's past. Life rolls on here at the same serene pace as in any other ordinary fishing village in the country. Most of its inhabitants still carry on the traditional vocation of their forefathers and live off the sea. Apparently, there is nothing to connect the little hamlet and its inhabitants with the space age.

Yet, for the world beyond, Tarapur is not this.

Time has seemingly telescoped to thrust Tarapur willy-nilly into the atomic era and gradually metamorphise the humdrum routine of an age-old village into a fast, exciting activity around one of the most advanced ventures in the country. Across a small bay, facing the village is the 380 MWe Tarapur Atomic Power Station, the first of its kind in India.

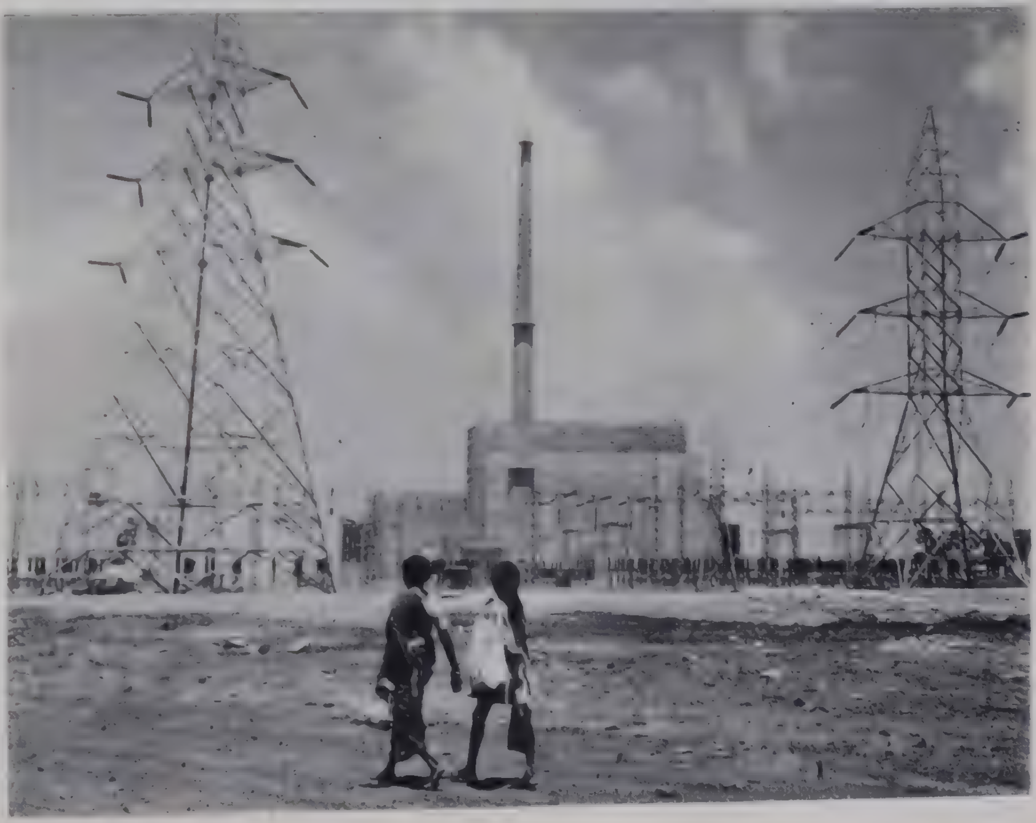
Today, Tarapur is synonymous with atomic power.

Power from the Station began flowing intermittently from April 1. Very soon its flow will increase to reach the rated 380 MWe which will be shared by the States of Maharashtra and Gujarat.

The completion of the Tarapur Station marks the beginning of the realization of a major objective in India's nuclear energy programme. For the late Prime Minister Jawaharlal Nehru and for the father of India's atomic energy effort, Dr. Homi Bhabha, this exciting event

(Continued on page 6)

Tarapur the village and, below, Tarapur, the atomic power station. The 220 KV towers of the transmission line to Gujarat and Maharashtra are on the left and right respectively



The Fast Breeder Reactor in India's Atomic Power Programme

NATURAL uranium has 0.7 per cent of U-235 isotope which is fissile. The fissile content can be increased by artificial enrichment. The power reactors at Tarapur use enriched uranium while the power reactors being built at Rana Pratap Sagar and at Kalpakkam would use natural uranium. During the operation of a reactor, the fissile material is burnt up. Simultaneously, the non-fissile U-238 gets converted into plutonium which is a fissile material. Also, another element, thorium which by itself is not fissile, when bombarded with neutrons, gets converted to U-233 which is another fissile material.

Enormous Possibilities

Fast Breeder Reactors are designed in such a way that during their operation, they actually produce more fissile material than what they burn up. Consequently, they hold out enormous possibilities for the production of electric power at low cost. According to studies made, fast breeder reactors are expected to produce the cheapest electricity by 1980s. Apart from the low generating cost, a major advantage of the fast breeder programme is that plutonium, which will be obtained as a by-product from our first generation nuclear power reactors now being built, can be used as fuel for fast reactors which will breed additional plutonium or uranium-233 by using depleted uranium (which is also a low cost by-product) of our first generation reactors, or thorium, which is plentiful in India. Such a programme could enable the efficient utilisation of the limited uranium reserves and the vast resources of thorium in India.

With the limited reserves of uranium, and in order to avoid import of expensive fuel material for the power reactor programmes, early steps have to be taken to develop a suitable breeder system. In view of these major considerations, the technology underlying the breeder system has to be developed early so that sufficient expertise is ready at hand as soon as plutonium is available for starting the fast reactor programme.

Arising out of these technological developments, India's nuclear power programme has been considered as consisting of three stages:

(1) Building of heavy water moderated reactors which would produce power as well as plutonium needed to start the breeders.

(2) Utilising the plutonium produced from stage-1 reactors in fast breeders. This stage would continue until suitable thorium-uranium 233 reactors become available.

(3) To run stage 2 type breeders on a thorium feed to produce uranium 233 and to run the second type of breeders on thorium-uranium 233 cycle.

Stage-1 has commenced. In less than ten years, it is expected that India would have installed about 3000 MWe of nuclear capacity producing sufficient plutonium to enable the construction of one 400-500 MWe fast breeder every year.

Developments Abroad

Considerable efforts have been expended by other countries in developing fast breeder technology. The development in some of these countries, especially in France, West Germany, United Kingdom, USSR and USA has reached a stage where construction of large prototypes has been taken in hand. Prototype reactors in the size range of 250-350 MWe are under construction 1000 MWe fast breeders will be [illegible]rational before 1980.

The Indian Atomic Energy Commission has decided to adopt the following plan of action:

(1) Construction of a small fast breeder test reactor by 1974-75 which would incorporate maximum possible parameters of a large prototype power reactor and which can also be used as a tool for advancing the fast breeder technology.

(2) Establishment of auxiliary laboratories.

The proposed fast breeder test reactor will be set up as part of the Reactor Research Centre which is being established at Kalpakkam near Madras. Two research projects, linked with the Reactor Research Centre at Kalpakkam are the Pulsed Fast Reactor Project and the Zero Energy Fast Reactor Project to be located at Kalpakkam and Trombay respectively The Pulsed Fast Reactor Project is for gaining experience in the physics of fast reactor design and to provide an important facility for acquiring basic data for fast neutron reactions. The Zero Energy Fast Reactor Project is a preliminary stage to the Pulsed Fast Reactor Project and is necessary for accurate design of the latter.

In view of the rapid strides which are being made by other countries in this field, it is possible to benefit from their experience and thus avoid spending large sums of money over a long period of time. For example, for the development of Fast Reactor technology, France has spent over Rs. 200 crores upto-date. By entering into collaboration with France the experience gained by her will be available to us at a small fraction of this cost.

In order to enable Indian scientists and engineers and industry to get acquainted with this new technology, a team of scientists was sent to France in 1968 for preparing a preliminary project report on the basis of experience gained by the French Atomic

(Continued on page 3, col. 1)

Atomic Energy Commission's Proposals For the Fourth Five Year Plan

THE main long-term objectives of the Department of Atomic Energy are as follows:

(a) Advanced research in basic sciences and the development of technologies involved in the atomic programme
(b) Development of atomic energy as a source of competitive electric power for industry and agriculture by building power stations in different regions and by developing new technologies, particularly related to India's resources
(c) Use of atomic radiation including use of radioisotopes in agriculture, industry, medicine, hydrology, oceanography and aeronomy
(d) Promotion of research and exploration of outer space and its utilisation for peaceful purposes; in particular, development of indigenous capability in advanced aero space engineering with rockets and satellites
(e) Development of indigenous capability and production of special metals, materials, fuels and equipment to support the atomic programme
(f) Training of scientists, engineers and technicians in the context of a widening programme for the application of atomic energy to the future needs of the nation
(g) Promotion of the use of materials and equipment emanating from the nuclear programme for further commercial applications through industrial organisations, with possibilities of export.

The Department has from the beginning aimed at self-sufficiency in the pursuit of the above objectives not only for saving scarce foreign exchange resources but also with an eye to national interest and uninterrupted execution of its programmes. The Department has, therefore, undertaken

(a) industrial activities to produce (i) fuels, (ii) special atomic materials, (iii) sophisticated electronic instrumentation and (iv) reprocessing of the radioactive by-products;
(b) surveying, prospecting and mining activities to obtain the necessary raw materials; and
(c) research and development activities in the many connected scientific disciplines and fields of technology not only to keep abreast with the new developments and techniques but also to develop new know-how. In addition to research in its own Departmental centres, the Department also promotes research in connected fields and mathematics by providing necessary assistance to certain institutions and universities.

The provisions proposed by the Atomic Energy Commission for inclusion in the Fourth Plan are shown in the Table on page 7.

Under the sector 'Industries & Minerals', the Commission proposed the following broad activities, viz:—

(i) the mining and milling of uranium, beryllium and other special heavy minerals
(ii) the extraction of thorium and zirconium
(iii) the production of enriched uranium fuel elements for Tarapur
(iv) the completion of the Nuclear Fuel Complex, work on which has already started at Hyderabad
(v) the production of heavy water for use as moderator and coolant for the CANDU reactors
(vi) the expansion in the production of sophisticated electronic equipments for the atomic power stations
(vii) the production of special purity materials for the electronics industry; and

(Continued on page 7)

479 Reactors by 1970

The latest survey of power and research reactors made by the International Atomic Energy Agency (IAEA) in its Member States shows that by the end of 1969, a total of 479 reactors will be operating. Of these, 105 are power reactors generating nearly 20,000 megawatts of electricity in 15 countries. The other 374 are for research, testing and training purposes in 48 countries.

Among the power reactors which have started operating this year are an experimental fast breeder reactor at Melekess, Soviet Union, designed for 12 megawatts of electricity, and twin boiling water reactors of 190 megawatts each, at Tarapur.

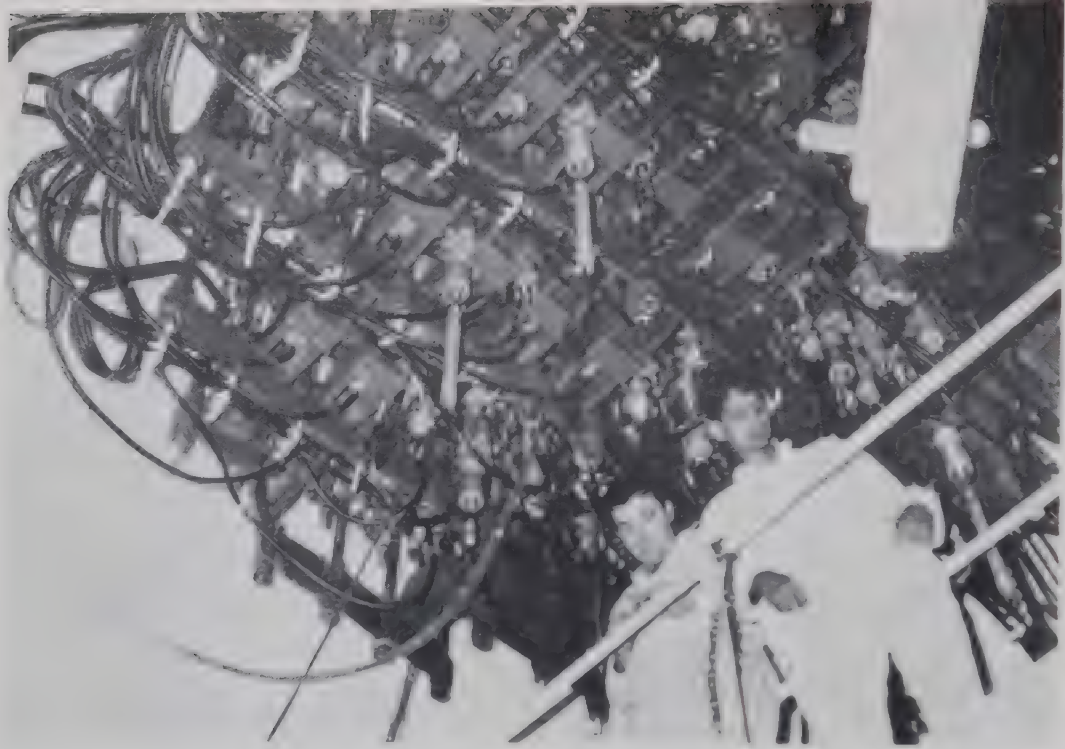
Estimates based on projects under construction indicate that by 1975, there will be 283 power reactors operating in 21 countries and generating nearly 130,000 megawatts of electricity.

Breeder Reactors

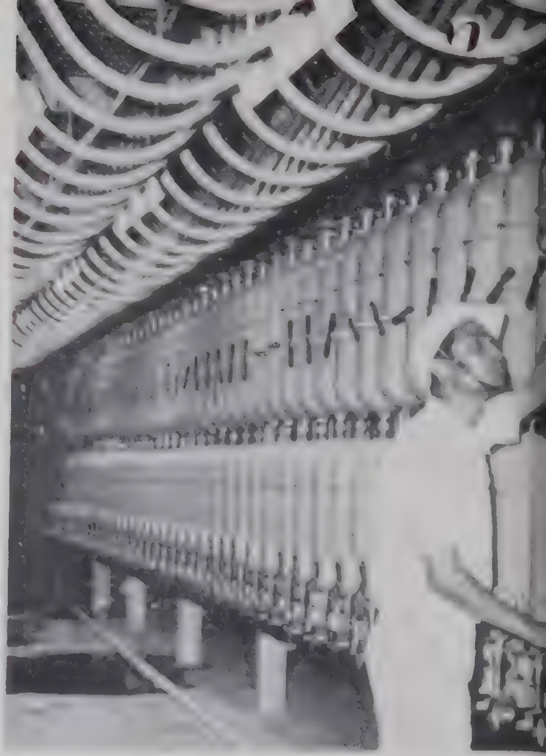
(*Continued from page 2*)

Energy Commission (CEA), in respect of their operating reactor RHAPSODIE. On the basis of the preliminary report, the Indian Atomic Energy Commission approved the second phase of the project to be undertaken with CEA to prepare, under the responsibility of the Indian Atomic Energy Commission, a complete project report which will detail the design and specifications of all plant components. An agreement to this effect was recently concluded between the Indian Atomic Energy Commission and CEA.

The whole project, including the construction of the reactor, will lie with the Indian Atomic Energy Commission and the Department of Atomic Energy, and Indian industry will have maximum share in the engineering of the project and supply of materials and equipment. ●



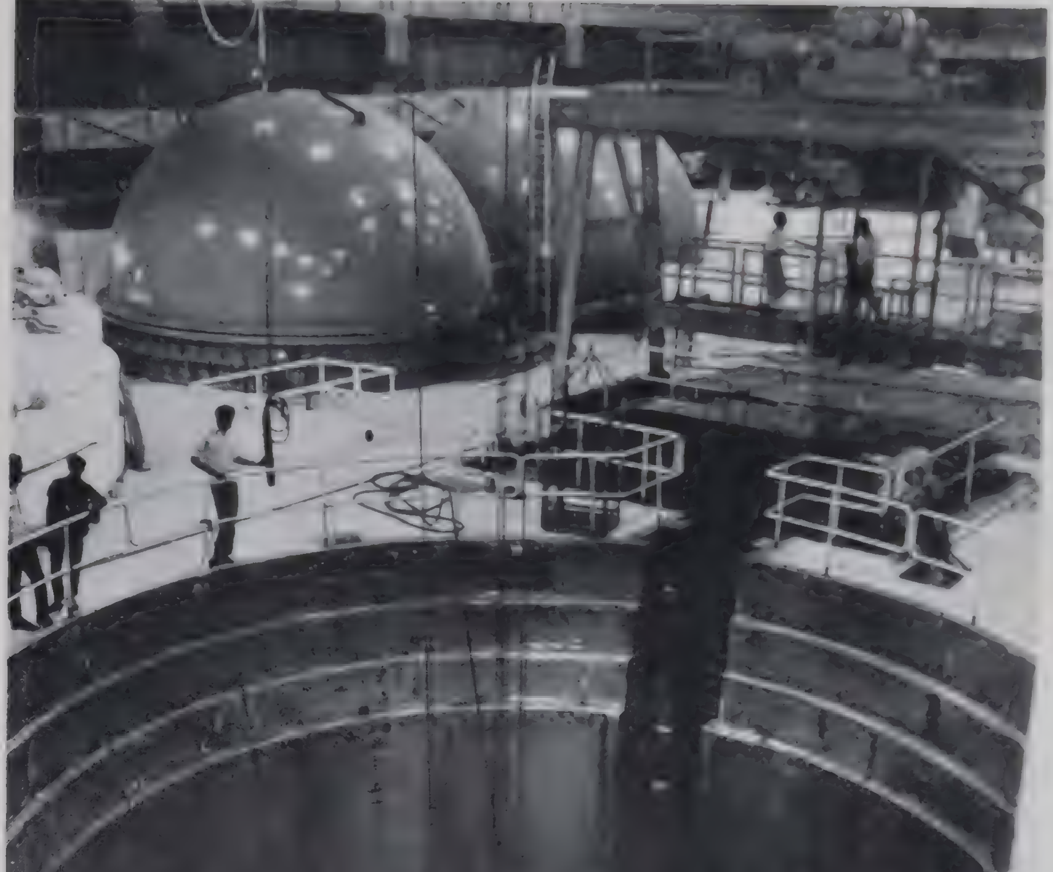
At bottom of reactor. Instrumentation for 'in core' power range monitor being connected



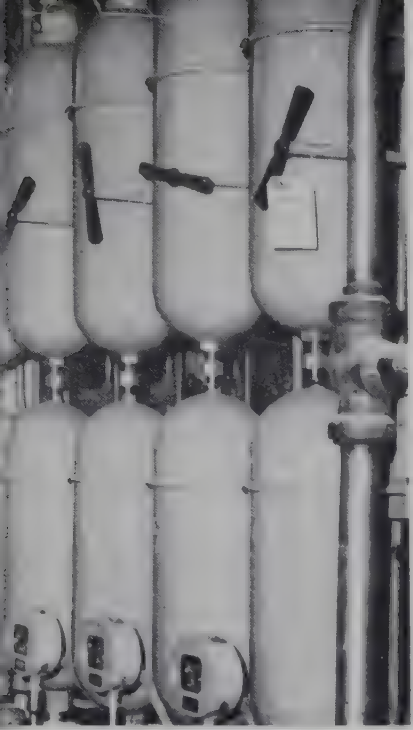
Control rod drive piping and hydraulic system

Tarapur Means Atomic

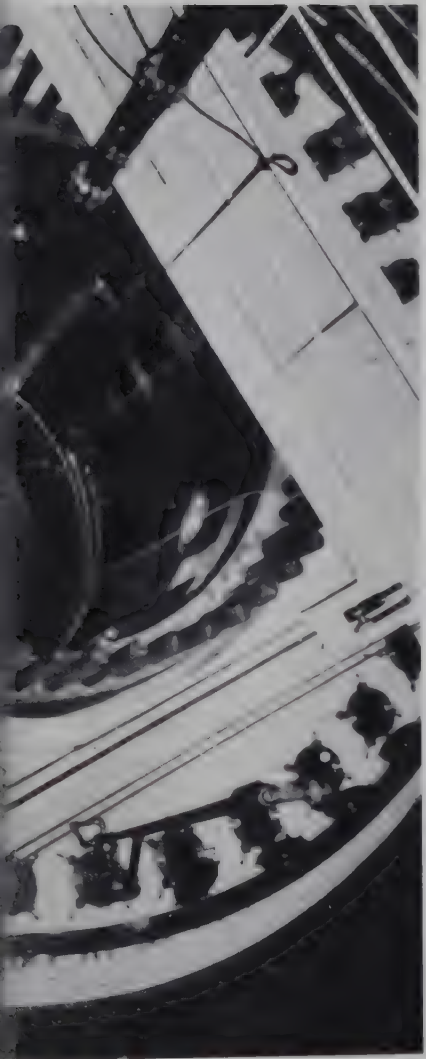
Operating floor in reactor building



Loading of fuel into reactor No. 1



Power



Top : Another view of the station, with the 112-metre exhaust stack. Bottom : The central control room

Tarapur Is the Largest Atomic Power

(Continued from page 1)

would have marked the fulfilment of a cherished dream, for both had recognized that for accelerating the country's pace of development, the atom alone held the answer. Back in 1961, Mr. Nehru had said in Trombay while inaugurating the Canada-India Reactor CIRUS, "If you have the picture of the future of India that you are trying to build, of the power that you require...you will come to the conclusion of the inevitability of our building up atomic energy for peaceful purposes..." Almost the same thought was expressed earlier by Dr. Bhabha in Geneva in 1955 at the First United Nations Conference on the Peaceful Uses of Atomic Energy when he said: "For the full industrialization of the under-developed countries...atomic energy is not merely an aid, it is an absolute necessity."

Beginnings

In August 1958, a decision was taken to include an atomic power station in the western region of India in the Third Five Year Plan. In the summer of 1960, Tarapur was selected out of twenty likely sites in the Bombay-Baroda region. Being highly industrialised, this region's demand for power runs far ahead of the available load. Lack of fossil fuel and hydro resources however severely restricts growth of conventional power capabilities. Hydro power potential in the region is low and fluctuating as the rivers, being mostly rain-fed, are not dependable.

Under the circumstances, nuclear energy was considered the best alternative. A nuclear power plant is a steady source of power unaffected by failure of rains. Besides, such a plant can operate at a high load factor in the region.

Tarapur is considered by experts to be one of the best sites for a nuclear power station. Being on the coast, the plant can draw cooling water, nearly 2,200 million litres per day, right off the sea. Besides, the site has a strong rock foundation, good meteorological and environmental conditions and, in the context of safety, has a low population density.

The prime contractor for the station is the International General Electric Company of the United States which was one of the seven bidders from the United Kingdom, France, Canada and the United States who responded to the global tenders invited by the Department of Atomic Energy. In December 1963, the United States Agency for International Development granted an aid of $ 80 million (approx. Rs. 60 crores) for the foreign exchange portion of the project. Out of this, a sum of $ 5 million (Rs. 3.75 crores) was deobligated in the course of the project as some equipment and services were procured indigenously.

The U.S. Atomic Energy Commission, under a contract signed in May 1966, provided enriched uranium oxide fuel worth $ 14.5 million (approx. Rs. 10.88 crores) for the initial charge, on a long term credit basis. Under the contract, the USAEC will continue to provide fuel throughout the life of the Station.

25-Year Life

Work started on the project in October 1964. At its peak, the station employed over 6,500 men working round-the-clock, seven days a week. When fully commissioned, it will be manned by a total staff of 370 only, and operated round-the-clock.

The Station consists of two Boiling Water type reactors, each helping generate 200 MWe. Heat created by the fission of uranium atoms boils water in the reactor core and the steam rising up is led under pressure, after drying, to the turbine which is coupled to a generator. The total power generated is 400 MWe, out of which 20 MWe will be consumed at the project itself while 380 MWe will be fed into the inter-State grid.

The life of the Station is about 25 years. Initially 40 tonnes of enriched uranium is fed to each reactor. No fresh fuel is required for two years. After that, both the reactors will together require about 22 tonnes per annum. Though fuel elements have been supplied by the U.S. for the first charge, in future, fuel will be fabricated in India itself out of the enriched uranium which will be imported from the United States.

Safety Features

One of the important considerations while setting up a nuclear power plant is safety. Apart from taking the first precaution of locating the plant away from a large town, a series of safety features have been built into the Tarapur plant system itself for arresting even infinitesmal degrees of radioactivity. This has been done by making the plant walls of thick reinforcement concrete and enclosing the reactors separately inside a shell of steel (drywell), each with a pressure supressing pool of water. In addition, exhausts are continuously monitored for radioactivity and are released into the atmosphere from a 112-metre-high stack. Data on environmental and dietetic radioactivity in the area has been collected over the past four years and the function is continuing. This data will provide the norms for measuring radioactivity fluctuations. Constant monitoring of environmental radioactivity will be a part of the operational functions at the station.

Fuel is transferred to and from the reactors under water, through an adjacent storage pool. The irradiated fuel residue will be reprocessed in a Reprocessing Plant that is being built at the site. This plant, being put up by the Bhabha Atomic Research Centre, will extract plutonium and residual uranium. When the technology of using plutonium in power reactors is perfected, the station can operate on plutonium fuel wholly or partially.

An idea of the fantastic difference in terms of economy and resources between a conventional thermal station and a nuclear one can be conveyed from the fact that to produce the same load of electricity as at Tarapur, it would require almost one million tonnes of superior grade coal per year or,

Plant in Asia

about three train loads per day as against only 22 tonnes per year of uranium !

In building this, the largest nuclear power station in Asia, American and Indian engineers and technicians have worked shoulder to shoulder on almost all aspects of the job. Indian project personnel have participated fully at every stage in giving shape to the Station — from drawing up specifications, reviewing and improving designs supervising erection, to the testing and commissioning of different units of the complex. Besides the services of the consultant's experts and the project staff themselves, specialist advice was made available by the Bhabha Atomic Research Centre at Trombay from time to time. The Bhabha Centre also did a good deal of work on the fabrication of control consoles and certain nuclear instrumentation, and supplying starting sources for reactors.

Immediate Impact

Today, atomic power comes down in meaningful terms to the man-in-the-street as he knows that the lamp he lights or the radio he tunes draw from the atom for their sustenance. The immediate impact of the Tarapur power station has been the withdrawal of power cuts which had been imposed in the region. Following this will be its widespread benefit to the farmers. Already there are plans to extend rural electrification, bringing in its wake greater use of pumps for irrigation and resultant boost to agricultural production. While Tarapur has ushered the era of atomic power in the country, two other stations presently in various stages of construction, will be joining it within the next five years. One station, of 400 MWe, is being built with Canadian assistance at Rana Pratap Sagar in Rajasthan State, while work on the first unit of 200 MWe of another, at Kalpakkam in the State of Tamil Nadu, has begun. The Kalpakkam station will mark another milestone in the advance of nuclear technology in India as almost 80 per cent of it will be indigenous.

Back to Bikini

The natives of Bikini Atoll are preparing to return to their island after 22 years of exile caused by the 1946 U.S. nuclear weapons tests. As they do so, their radioactive body burdens will be monitored by Dr. Robert A. Conard of Brookhaven National Laboratory, who has worked with Marshall Islanders for 15 years. The monitoring will centre around urine analysis and whole body count. Dr. Conard has already begun to take samples from work parties of Bikini natives, who are preparing to leave Kili Island and make Bikini habitable once again — a job which is estimated to take six years.

New Research Reactor ZPPR in Operation

A NEW reactor for applied research has gone into operation at the USAEC's National Reactor Testing Station in Idaho. Designed and operated by Argonne National Laboratory, the new facility is called the ZPPR — Zero Power Plutonium Reactor. It is scheduled to play an important role in the development of breeder reactors by obtaining physics data from such experiments as plutonium criticality measurements, the effect of sodium loss or fuel movement on the stability or reactor power, and a determination of the energies of neutrons present in the reactor core. *(Nuclear News, June* 1969). ●

AEC's Fourth Plan Proposals

(Continued from page 3)

(viii) the recovery of plutonium and uranium from irradiated fuel elements from the power stations.

The industries and minerals programme here envisaged is substantially based on the proposals for the nuclear power programme.

The proposals for the manufacture of heavy water include the following :

Name of the plant	Capacity (tonnes/year)
(1) Nangal (already commissioned)	14
(2) Rana Pratap Sagar (under construction)	100
(3) One ammonia based plant	60
(4) One additional plant	250

At the Nuclear Fuel Complex at Hyderabad, the following plants are under construction :

Name of the plant	Capacity (tonnes/year)
(1) Uranium Oxide Plant	125
(2) Ceramic Fuel Fabrication Plant	100
(3) Enriched Uranium Oxide Plant	36
(4) Enriched Uranium Oxide Fuel Fabrication Plant	30
(5) Zircaloy Plant	50

The following Plutonium Fuel Reprocessing Plants are being built :

(1) At Tarapur — 500 kg of contained uranium per day

(2) Second Plant — 500 kg of contained uranium per day

TABLE

Provisions proposed for inclusion in the Fourth Plan

	Rs. in crores
i) Research & Development including Space Research	94.00
ii) Industries and Minerals including Public Sector Undertakings	82.00
iii) Nuclear Power	212.00
Total :	388.00

Dr. D. N. Wadia—A Father Figure in Indian Geology

INDIA lost an outstanding man of science with the passing away of Dr. D. N. Wadia on June 15. At 86, Dr. Wadia was fully active in the affairs of the Atomic Minerals Division of the Department of Atomic Energy in his capacity as Geological Adviser to the Department and the Atomic Energy Commission.

Born October 23, 1883, in Surat, Dr. Wadia started his career in 1907 as a lecturer in Geology in the Prince of Wales College, Jammu. In 1921, he took up appointment with the Geological Survey of India which he held upto his formal retirement in 1938. It would not however be correct to use the word 'retirement' in the case of such an active worker as Dr. Wadia for, after 1938, he continued to serve in various capacities. He was successively Minerals Adviser to the Government of Ceylon, Geological Adviser to the Government of India, first Director of the Indian Bureau of Mines, and finally, Adviser to the AEC.

During his term with the Geological Survey, Dr. Wadia continued his valuable researches on the geology of the North West Himalayas. His work on the structure and stratigraphy of this region is considered to be among his finest contribution to Indian geology. In 1919, two years prior to joining the GSI, Dr. Wadia brought out his book "Geology of India and Burma," almost the first text book on the geology of this subcontinent. Apart from enlarging the knowledge of this area, the book has been a source of inspiration and influence to generations of Indian geologists.

In addition to his contribution to Indian geological research, Dr. Wadia's efforts in the survey and prospecting of atomic minerals is particularly significant. He became associated with the Atomic Energy Commission in 1949 when the Rare Minerals Survey Unit was set up under the atomic energy programme. From a staff of three officers, the Unit, now called the Atomic Minerals Division, has grown to the strength of 1050. Dr. Wadia continuously guided the programme of the Division which is responsible for prospecting and surveying atomic minerals and for development of promising deposits. A working uranium mine at Jaduguda in Bihar is an achievement of significance flowing from his work. This development has made India self-sufficient in this important raw material for the on-going programme of atomic energy.

International Recognition

Dr. Wadia was particularly interested in the mining of low-grade uranium ores and in developing efficient processes for extracting uranium from them. He also pursued work for the recovery of other minerals such as nickel, molybdenum and copper and, largely due to his leadership, the Atomic Energy Commission is now working on the possibility of commercial exploitation of these from uranium ores.

Dr. Wadia's original work won for him national and international recognition. In 1957 he was elected Fellow of the Royal Society, London. In 1958, in recognition of his outstanding contribution to Indian science, the Government of India awarded him the Padma Bhushan. And in 1963 another honour was bestowed upon him when he was made the first National Professor of Geology. He was twice President of the Indian Science Congress, President of the National Institute of Sciences (of which he was also a founder-member), twice President of the Geological, Mining and Metallurgical Society of India, and President of the Geological Society of India.

A Pioneer

With long years of total dedication to his work, this father figure of Indian geology has left a deep impress on the nation. In the words of the Acting President of India, Shri V. V. Giri, Dr. Wadia's passing away "is an irreparable loss to the country. A grateful nation will always remember his outstanding contribution to Indian geology". The Prime Minister Smt. Indira Gandhi said Dr. Wadia's work was of immense significance in the location and development of geological resources. "The Atomic Energy Commission will be specially grateful to him. He did not spare himself and he died in harness."

Paying tribute to the late scientist at a condolence meeting held at the Department of Atomic Energy, Dr. Vikram A. Sarabhai, Chairman of the AEC said that in the death of Dr. Wadia, India had lost one of its pioneers in the field of atomic energy.

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NUCLEAR INDIA

VOL. 7. NO. 12 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY AUGUST 1969

An Electron Beam Welding Unit Made at Trombay

AN electron beam welding unit, an extremely useful tool in advance technologies such as those relating to space, nuclear energy, aircraft, electronics etc., has been designed and built by the Technical Physics Division of the Bhabha Atomic Research Centre, Trombay.

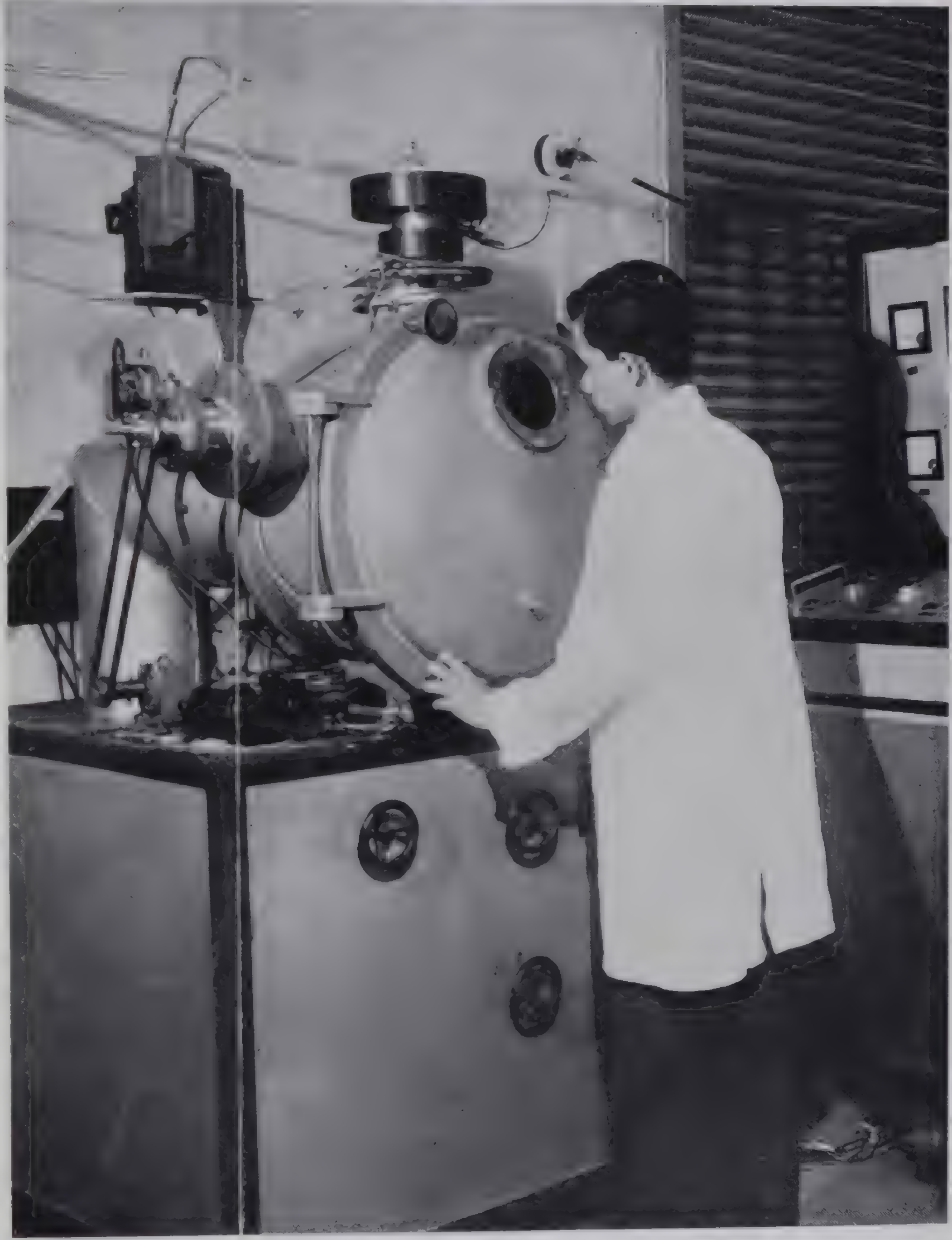
With the special high heat-resistant and atmosphere-sensitive materials used in these areas, such a unit is almost indispensable as it enables high-temperature welding in vacuum.

The electron beam welding process owes its development primarily to nuclear industry. Nuclear reactors require a number of assemblies fabricated out of refractory and reactive metals. Any failure of these assemblies can have costly and disastrous results because even minute quantities of gases can seriously impair their physical properties. Some of the typical materials which are most often involved in this industry are zircaloy, columbium, titanium, special aluminium alloys etc.

High Energy Concentration

The basic principle on which this system operates is fairly simple. A tungsten filament is heated to generate free electrons which are accelerated towards the workpiece due to the electrical potential that is maintained between the filament and the piece. Sometimes an anode is also placed between the two. This potential determines the energy imparted to the electrons, which subsequently appears as heat in the workpiece.

The electron stream is directed on the piece by either electrostatic or electro-magnetic focusing. Although electro-static focusing is simpler, electro-magnetic focusing yields a narrower beam and thus enables a higher concentration of energy.



The BARC-developed electron beam welder with its high voltage power supply.

The electron gun and the pieces to be welded are enclosed in a vacuum chamber. As can be seen in the photograph on page 2 the machine consists of a 610 mm-diameter stainless steel chamber with several side ports welded to it. The electron gun is mounted on the top port while the sideports are used for mounting mechanisms for transmitting linear as well as circumferential motion, thro-

(Continued on page 2)

Electron Beam Welding Is a Must in Nuclear

(*Continued from page* 1)

ugh vacuum seals. The welding operation can be watched through a special viewport provided on the front cover. Also, the welding parameters can be controlled from a control panel located outside.

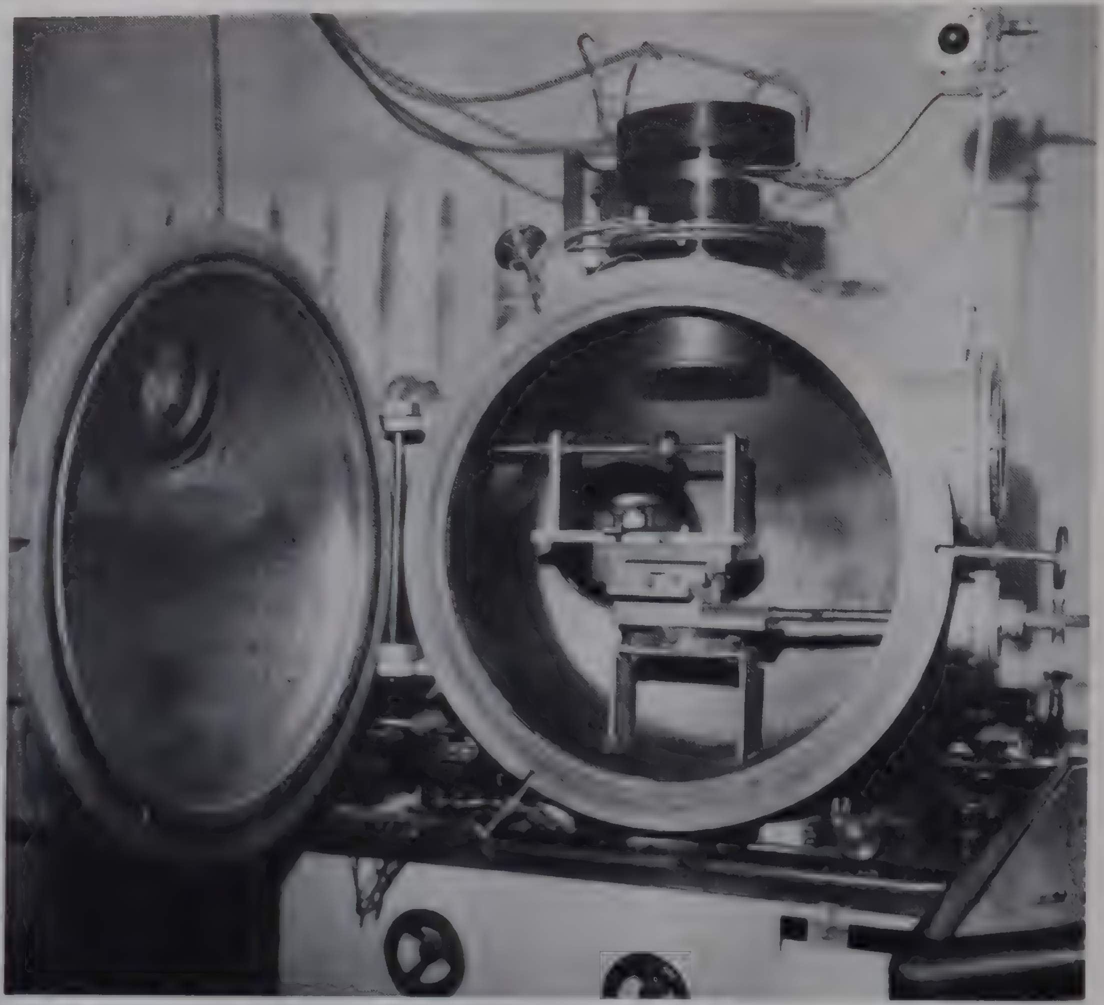
During the welding operation, a pressure of less than one micron must be maintained to achieve a high degree of concentration of electrons. The vacuum system in the unit is designed to give an operating vacuum of 5 x 10^{-5} torr (mm of mercury) in thirty minutes from cold start. This is achieved by employing a 225 mm-diameter high vacuum oil diffusion pump which is backed by an oil sealed rotary pump of 450 litres per minute capacity. The vacuum is measured by means of a combined thermocouple-cum-penning gauge unit, also fabricated by the Division.

Heart of Equipment

Linear welding is carried out by clamping the weld pieces together on a work table mounted inside the chamber. As can be seen in the photograph the work table is capable of transverse and longitudinal motions in the horizontal plane. These motions are transmitted from the variable speed D.C. motors located outside the chamber, through rotary vacuum seals. Pieces as long as 150 mm can be welded in both the directions. Similarly, circumferential welding of upto a maximum of 150 mm diameter can be achieved by another variable speed D.C. motor.

The heart of the equipment is of course the electron gun system which can produce a beam whose minimum spot size is 1.5 mm. The high voltage power supply for the gun provides a maximum voltage of 30 KV with maximum current capacity of 200 mili-amperes D.C., both voltage and current being continuously variable. In this way very precise energy control is possible.

The whole unit has already been tested thoroughly and various refractory, reactive and dissimilar metals have been welded accurately. Thin walled stainless steel tubes (one mm thick), tantalum tubes, nimonic alloy drill fixtures, kovar eyelets for image intensifier tubes, stainless steel sheets, copper sheets etc. are some of the typical items which have been welded successfully in this unit.



View of the interior of the vacuum chamber with its various drives for linear and circular motions. Kovar eyelets can be seen mounted for circumferential welding.

The cost of the unit is estimated to be Rs. 1,25,000 which includes a foreign exchange component of Rs. 15,000. Against this, the total cost of an equivalent imported unit would be around Rs. 2,00,000.

A few characteristic advantages of such a system are enumerated here to stress its importance in applications involving refractory and reactive metals like tantalum, molybdenum, columbium, titanium, zirconium etc.

As the welding process is carried out under a high vacuum of 10^{-5} torr gaseous contamination is considerably reduced. This condition also eliminates the necessity of using flux. In addition, the vacuum helps to remove the occluded gases from the molten mass as there is a significant difference in vapour pressure between the gases and the atmosphere.

Deeper Penetration

The beam can be focussed to a very high power density, of the order of 10^8 watts/sq.cm. Against this, the maximum power density that can be attained by the best arc welding is about 10^5 watts/sq.cm. Such high power density helps to narrow the heat-affected zone in the workpiece considerably. Also, with its high voltage, the electron beam can penetrate deeper into the weld. Normal electron beam welds can achieve a depth-to-width ratio of 5:1 while in special cases a ratio of 20:1 has been attained.

The power input for welding can be controlled instantaneously and precisely, as voltage and current can be

Industry

varied smoothly from zero to the maximum. Once welding parameters are determined for any particular weld metal, an accurate heat input can be maintained.

As the electron beam is focussed and deflected electro-magnetically, it also lends itself to automatic programming for complex configurations.

Besides the nuclear industry, the elctron beam welding process is used in the aerospace and the electronic industry, to name only two. In the aerospace industry, the process enables welding of joints possessing outstanding high temperature properties, best 'strength-to-weight' ratios, high resistance to thermal cycling and high elastic modulii. Missiles, rockets, spaceships and their various components have been brought closer to reality by the rare virtues of electron beam welding.

In Electronics Industry

A typical metal used in this area which has so much exasperated welding experts is Beryllium. Its modulus of elasticity, low density and its thermal properties have made it an important structural material in the aerospace industry despite its inherent natural brittleness. But by this process it has been possible to weld this metal satisfactorily. Similarly, a number of stainless alloys as well as a variety of super alloys have been joined successfully with this method.

In the electronics industry, because the electron beam is the only convenient fusion welding process to work in high vacuum, and because, with the proper feed rates, it assures a vacuum tight joint, it has obvious advantages for fabricating products from which air has to be evacuated. This process for instance can be used to cut costs and rejections in the production of vacuum tubes and evacuated electronic assemblies.

Electron beam welding is slowly making inroads in micro-electronics industry also. With the heavy dependence of modern industry on electronics day by day, it should play an

(Continued on page 8)

Bhatnagar Award for BARC Scientist

Shri A. S. Rao, Director of the Electronics Group in the Bhabha Atomic Research Centre, receiving the Shanti Swarup Bhatnagar Memorial Award from the Prime Minister Smt. Indira Gandhi. Shri Rao received the Award for the year 1965 for outstanding contribution to the Engineering Sciences. The presentation ceremony took place at New Delhi on July 28, 1969.

Gauribidanur Symposium on Seismology

ON July 4 and 5, Indian earth scientists met at Gauribidanur, about 80 kms. north of Bangalore, to discuss developments in seismology and applications of the data from the Gauribidanur Seismic Station for seismological research in the country.

Installed, in a partial form around the end of 1965, primarily for detecting underground nuclear explosions, by the Bhabha Atomic Research Centre in collaboration with the United Kingdom Atomic Energy Authority (UKAEA), the Gauribidanur array and associated facilities are continuously being improved and extended to provide seismological data in a form suitable for analysis by computers. The station which is now functioning with a full complement of 20 sensors, deployed over an area of 25 kms by 25 kms, provides data of immense use for study of seismic features of India and the internal structure of the earth.

Organized by the Bhabha Atomic Research Centre, the symposium was attended by scientists from the India Meteorological Department, the Council of Scientific and Industrial Research, the Geological Survey of India, the Mysore Geological Survey, the Kolar Gold Mine Undertaking, the Universities of Bangalore, Banaras and Kurukshetra, and the Bhabha Centre.

Among the various topics discussed at the symposium were: the role of arrays and computers in seismological research, crustal studies using surface and body waves, the present status of seismological research in India, seismic source mechanism, phenomena of rock bursts in deep mines, model studies, and geological features of Southern India.

The symposium established guidelines for disseminating data from the station. Also, realizing the importance of studying the seismicity of Southern India, especially the Deccan Plateau,

(Continued on page 8)

The Cavendish —

(Exerpted from "A

IT has been said that the Cavendish Laboratory is as old as the age of science in modern civilization. Born out of the need for scientific education and research in industrial society, the Cavendish established itself as Britain's, if not Europe's or the world's leading research institution.

Established in 1871 at Cambridge University, the Cavendish Laboratory is famous for its contribution to nuclear physics. It has trained most of Britain's outstanding physicists, and research laboratories of the world are staffed by former Cavendish students and researchers.

A chancellor of the University of Cambridge, the seventh Duke of Devonshire, whose family name was Cavendish, donated the cost of the first building out of his own pocket. As still occurs today, the cost, 8,450 pounds, was 20 per cent over the estimate. It was named the Cavendish Laboratory in honour of its donor.

James Clerk Maxwell, the first of a series of great scientists to direct the Cavendish, was appointed Professor of Experimental Physics to head the new laboratory in its initial years. Maxwell had to operate on a modest budget; classes were small and no female students were allowed to attend except when the professor was away on summer vacation. Before he died in 1879, at age 48, he had ushered in the age of experimentation. Maxwell's theory of electromagnetic waves led to the development of radio communication.

Discovery of Argon

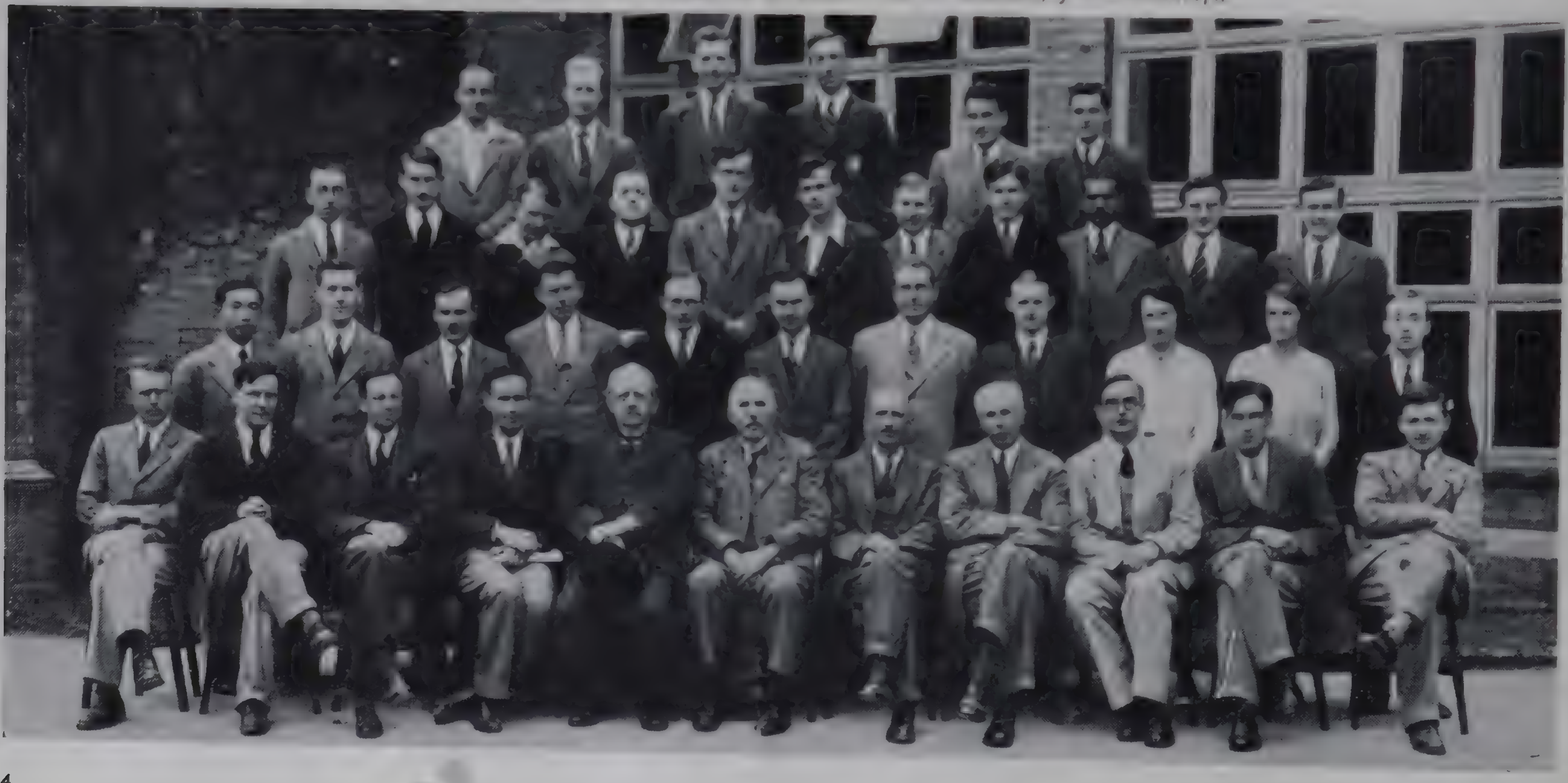
Lord Rayleigh (the third), his successor, was one of the greatest classical physicists of all time. He remained at the Cavendish for only five years, resigning in 1885 to return to his large dairy farm and establishing Lord Rayleigh's Dairies in London in 1887. He is noted for determining with a high degree of accuracy the measurement of the ohm, one of three fundamental units of electrical measurement. Later, by investigating a small discrepancy between the density of chemical and atmospheric nitrogen, he, with Sir William Ramsay, discovered argon, an important inert gas now used to fill electric light bulbs. For this discovery he was awarded the Nobel prize in Physics in 1904. He donated his prize money for construction of a new wing on the Cavendish Laboratory.

J. J. Thomson was chosen to succeed Lord Rayleigh in 1885. It was an inspired choice for he was to remain head for 34 years, and if not the most famous of those who held the Cavendish chair, he was perhaps the most important. His major achievement, the discovery of the electron, stands at the beginning of all atomic research.

Thomson established a tradition which seemed to promote success. There was a pervading atmosphere of sincerity and comradeship among teachers and scholars, the already famous and the mere beginners.

Many stories—true or invented—describe "J.J." as a typical example of that now extinct species, the absent-minded professor. His pet sub-

Professors and students at the Cavendish (June 1932). Back Row : N. S. Alexander, P. Wright, A. G. Hill, J. L. Pawsey, G. Occhialina, H. Miller, Second Row: W. E. Duncanson, E. C. Childs, T. G. P. Tarrant, J. McDougall, R. C. Evans, E. S. Shire, E. L. C. White, F. H. Nicoll, R. M. Chaudhri, B. V. Bowden, W. B. Lewis. Third Row : P. C. Ho, C. B. Mohr, H. W. S. Massey, M. L. Oliphant, E. T. S. Walton, C. E. Wynn-Williams, J. K. Roberts, N. Feather, Miss Davies, Miss Sparshott, J. P. Gott. Sitting : J. A. Ratcliffe, P. Kapitza, J. Chadwick, R. Ladenberg, Prof. Sir J. J. Thomson, Prof. Lord Rutherford, Prof. C. T. R. Wilson, F. W. Aston, C. D. Ellis, P. M. S. Blackett, J. D. Cockcroft.



ursery of Genius

'', February 1969)

ject was electric discharge in gases—ionization. His preoccupation with ions was almost a joke at the Cavendish and his students composed songs for the meeting of the Physical Society, to be sung after the meal (with the professor as guest). One of them, to the tune of Clementine, ran:

In a dusty lab'ratory
'mid the coils of wax and twine
There the atoms in their glory
Ionize and recombine.
Chorus: Oh my darlings,
Oh my darlings
Oh my darling ions mine
You are lost and gone forever
When just once you recombine.

Under his direction, the teaching at the Cavendish Laboratory became world famous and many of the most prominent figures of subsequent atomic research studied there. During Thomson's tenure F.W. Aston invented the mass spectrometer and C.T.R. Wilson developed the first cloud chamber.

Arrival of Rutherford

In 1895 a change in the regulations at the university proved to be of the greatest importance to science and to the Cavendish. Promising graduates from any country were permitted to attend as research students and the Cavendish became the meeting place of young scientists from all over the world.

One of the first was Ernest Rutherford of New Zealand. His work had far-reaching consequences for the history of science. He developed the theory of radioactivity, discovered the atomic nucleus, and was the first to disintegrate the atom by artificial means. Later the scientist-author C.P. Snow was to write: "Rutherford is very likely the major scientific figure since Newton."

When Rutherford arrived, Thomson suggested that he work with him on the conduction of electricity through gases. Their subsequent collaboration in those years was particularly fruitful, and as a result of his research Rutherford was offered the Macdonald professorship of the new physics laboratory at McGill University. He accepted and travelled to Montreal in 1898 to take up his new post at the age of 27. He next became director of the Manchester University Laboratory in 1907 and did not return to the Cavendish until 1919 when he succeeded Thomson.

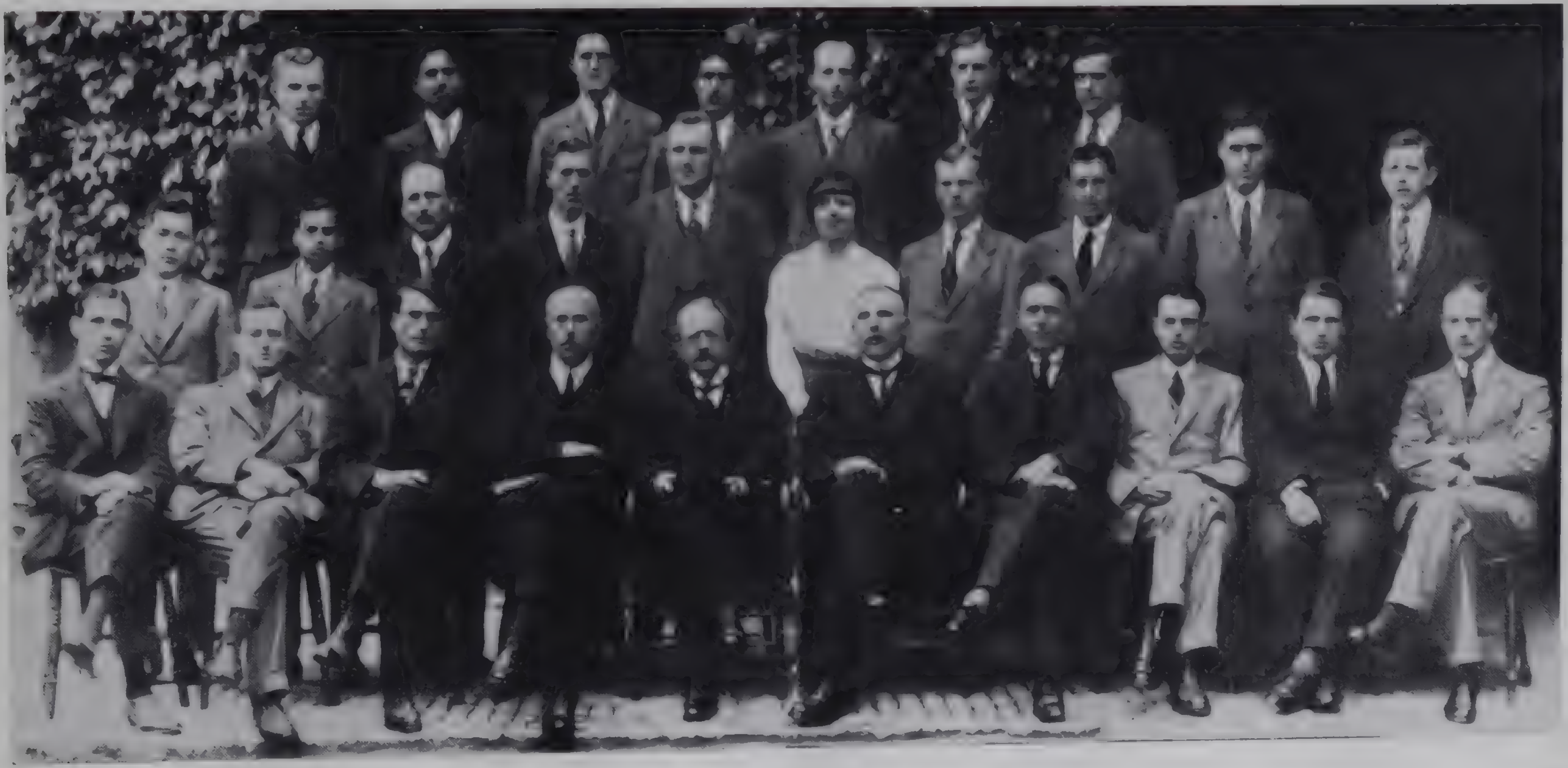
Machine Age

The '20s and '30s were most exciting times at the Cavendish. Aston returned to perfect his mass spectrograph and succeeded in determining the principal isotopes of the gases. P. M. S. Blackett used Wilson's cloud chamber to photograph the process of atomic disintegration discovered previously by Rutherford. Later, Blackett and his colleague G.P.S. Occhialini investigated cosmic rays, confirming the positive electron in the same year that Chadwick discovered the neutron.

John Cockcroft, with E.T.S. Walton,

(Continued on page 6)

CAVENDISH LABORATORY 1922. Back Row: *E. Madgwick, B. N. Banerji, H. D. Smyth, N. H. Ahmad, W. T. Gibson, L. L. White, P. L. Kapitza,* Middle Row: *Y. Nishina, A. C. Chakravarti, P. Mercier, J. E. Crackston, H. Robinson, Miss M. Taylor, E. S. Bieler, J. K. Roberts, P. M. S. Blackett, E. C. Stoner.* Sitting: *M. H. Belz, G. H. Henderson, D. A. Keys, F. W. Aston, Sir J. J. Thomson, Sir Ernest Rutherford, J. A. Crowther, G. Stead, E. V. Appleton, A. Muller.*



Rutherford and the Golden Age of Physics

built the world's first particle accelerator at the Cavendish. Its start-up in 1932 ushered in the machine age of research. For their subsequent experiments with the machine, Cockcroft and Walton were awarded the Nobel Prize for physics in 1951.

Other achievements during this period at the Cavendish included Ratcliffe's extension of Appleton's work on the wave-reflecting layers of the atmosphere which formed a solid base for development of radar; Bullard's study of the interior of the earth; and Bernal's work on crystal structure. The latter laid essential foundations for the later attack on the structure of proteins.

Peter Kapitza's story is an interesting one of the times. Kapitza, son of a Tsarist general, came to the Cavendish as a research student. In his 14 years at the Institute, his distinguished work earned him his own laboratory for magnetic field and low temperature research. In 1934 he visited Russia where he was asked to stay on as his country needed him. Rutherford arranged to send to Moscow much of the apparatus Kapitza had been using. In return, Soviet authorities provided funds to re-equip his Cambridge laboratory for other work.

The two decades under Rutherford have been called the golden age of physics, with their rapid succession of discoveries. With his death in 1937 a great chapter in the history of the Cavendish came to an end.

War Effort

Sir Lawrence Bragg was elected to the Cavendish professorship in 1938 and John Cockcroft Jacksonian professor in 1939. The clouds of war were gathering and Cockcroft submitted a list of scientists at the Cavendish whom he believed would be of value to the war effort. These scientists were of tremendous assistance to Britain. Cavendish people were the first to be introduced to the secrets of radar and gained experience manning the early radar stations. No doubt Britain's lead over Germany in radar technique was largely sustained by the young men of the Cavendish.

When France fell, the famous scientist Joliot sent his two assistants to Britain. Hans von Halban and Lew Kowarski arrived there with some 36 gallons of priceless heavy water, almost all of the world's supply. Halban's and Kowarski's subsequent journey to the Cavendish in a second hand car was an adventure. They were not, as aliens, allowed to have maps. All signposts had been taken away in anticipation of invasion. Kowarski learned before leaving London the combination of the names of the inns in the villages on the route and by this means they found their way. The two eventually joined the Montreal project. Kowarski was in charge of the ZEEP reactor at Chalk River when it first reached criticality in 1945.

Genetic Code

During the latter part of the war Sir James Chadwick led to the United States a British team which contributed to the construction of the first atomic bomb. Cockcroft was invited to head the Chalk River Project which ran concurrently with the famous Manhattan project during the last year of the war. At war's end Henry Smyth (an American, Cavendish class '22) wrote the famous "Smyth Report", the only published account of the early years of the United States atomic energy programme.

Lawrence Bragg, in collaboration with his father William Henry Bragg, developed X-ray analysis of the arrangement of crystalline structures and they were awarded the Nobel prize for their work in 1915. During his term as head of the Cavendish he initiated work on protein structure. Its analysis by X-rays grew into one of the glories of the Cavendish.

In 1953 Dr. Francis Crick and American scientist Dr. J. D. Watson, studying at the Cavendish, suggested a new theory about the structure of deoxyribonucleic acid, DNA for short, the actual substance of the genes, the theoretical units of heredity.

One of the most remarkable characteristics of living beings is their ability to pass inherited features from one generation to the next, and one of man's greatest scientific triumphs has been the discovery of the method by which genes transmit and translate the message of heredity. It was Watson and Crick who clarified the nature of the genetic code.

Intriguing Pulsars

The Cavendish is currently under the directorship of Professor Sir Nevill Mott. About a quarter of the work is radio astronomy and the Cavendish has an observatory at Lord's Bridge, five miles south of Cambridge. The construction of a new radio telescope was completed in 1963. The new instrument can receive powerful emissions from radio sources in the universe. Last year the group discovered pulsars, tremendously strong radio signals of very short duration. The source of the signal is estimated to be 1,000 times more distant than the sun. The first four pulsars were discovered by Cambridge, but since their existence was made public they have been studied with all the large radio telescopes and have caught the interest of astronomers around the world. The signals or pulses are received almost in the form of a message.

Certainly no radio astronomer has concluded that the pulses are signals being transmitted by another society—but for one inclined to accept such a theory the pulsar signals are perhaps the most "artificial" discovered so far.

The Cavendish has interacted vigorously with the forces that transformed mankind's way of life in the last 10 decades; it has fulfilled its promise many times over and established itself as a leading research institution. There is no institute in the world whose men have collected so many honours and prizes. The famous laboratory will celebrate its centennial in 1971. Will it be announcing another breakthrough—another new scientific achievement in the Cavendish tradition? ●

A view of the Earth from the Moon taken during Apollo-10 flight. (Photo: Courtesy USIS)

"Triumph of the Irrepressible Spirit of Man"

PERHAPS at no time in history has a single event drawn such a whole-hearted involvement of mankind as the fantastic landing on the Moon. It can be truly said that this was an happening in which millions of men and women from almost all corners of the world participated, identifying themselves spontaneously with the intrepid voyagers and their mission.

Aeons ago, according to one theory, a part of the Earth separated to form the Moon. Since those primordial days when terrestrial life even in its rudimentary form had yet to make its appearence, a sort of close physical relationship has existed between the two.

When Man evolved into his present form, his innate urge to reach out was, in a way, a manifestation of this relationship. Down the ages he has reached out to the Moon and the planets in myths and legends and, as the idea inexhorably inched closer to realization in recent decades, in the pages of science fiction. The age-old dream is now a fact. The scientist has removed the Moon from the poet's horizon and placed it under the microscope. With it he has also struck off the aura of romance which enveloped the heavenly body. But this development has also extended the scope of man's imagination and introduced a new dimension to adventure and romance as rich as that of the past. Scientific discovery and technological advance are concretising the persistent idea of modern day prophets, the space fiction writers, and interplanetary travel is now a matter of serious thought in competent circles.

Viewed against this, the epoch-making achievement of Armstrong, Aldrin and Michael Collins and the thousands of men and women behind them is truly a giant leap for mankind. These daring men and women represent in its totality the tenacious spirit of Man and his innate quality of eternal striving towards perfection. We can do no better here than echo the words of Prime Minister Smt. Indira Gandhi when she said that the men who walked on the Moon "are delegates of the irrepressible spirit of Man—the spirit which crosses oceans on a bundle of reeds and leaps from one celestial body to another in a small vehicle of its own making." The entire achievement "is surely the greatest and most daring of scientific achievements, a proud moment for the people of the United States and indeed for all mankind."

Symposium on Macromolecules at Bhabha Centre

A symposium on "Macromolecules in Storage and Transfer of Biological Information" organized by the Biology and Medical Committee of the Department of Atomic Energy will be held at the Bhabha Atomic Research Centre, Trombay, Bombay-85 about mid-December 1969. The scientific programme will include sessions on: Ultrastructure of cells and electron microscopy of DNA, Nucleic acid structure and function, Transcription and translation of nucleic acids, Regulatory mechanisms, Function of cellular membranes, nature and repair of radiation damage.

The last date for sending abstracts for contributed papers is September 30, 1969. The abstracts may be sent to Dr. N. K. Notani, Biology Division, Bhabha Atomic Research Centre, Trombay, Bombay 85.

MICROWELDING BY LASER. A laser that can apply the energy of a laser beam with a very high degree of precision has been developed by the International Research and Development Company at Newcastle upon Tyne in north-east England. Called a laser micro-welder, the new instrument consists of a small pulsed ruby laser mounted onto a microscope; this allows the laser light pulses to be fired down the optical axis of the microscope, thus enabling great accuracy to be obtained in welding

Gauribidanur Symposium

(Continued from page 3)

it also mooted a cooperative research programme for surveying the crust and upper mantle by firing chemical charges at suitable locations in relation to Gauribidanur.

For obtaining precise information about earthquakes of importance the participants agreed that a scheme should be evolved for exchanging data among seismograph networks in the country and analysing them on a centralized basis.

The scientists recognised that the Gauribidanur system and the computer-based processing facilities developed at the Bhabha Atomic Research Centre, offer excellent scope for seismological research in Universities and Government research centres.

Dr. R. Ramanna, Director, Physics Group of the Bhabha Atomic Research Centre, inaugurated the symposium and acted as moderator at the panel discussions which followed. Dr. Ramanna pointed out that the array centre was a national facility and its data would be freely available to all research workers subject to the financial implications of duplication.

Industrial Type Electron Unit Being Developed

(Continued from page 3)

important role in the near future in this industry too.

Despite its outstanding advantages, the process has also some limitations. For instance, the maximum size of the workpiece that can be welded by this method is limited by the dimensions of the vacuum chamber. To extend its range of use, the Technical Physics Division is presently working on an atmospheric type electron beam welding apparatus. In this device, the electron beam is generated and accelerated to a voltage of 150 KV in high vacuum and is then led through a differential pumping system to a region of atmospheric pressure of an inert gas, where welding can be carried out. Workpieces of very large sizes can then be welded with all the advantages of electron beam welding enumerated earlier.

The Division has also developed and standardised laboratory-type electron beam melting furnaces. One such unit has already been supplied to the National Metallurgical Laboratory, Jamshedpur. ●

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NUCLEAR INDIA

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Rocket Propellant Plant Starts Production

THE Thumba Rocket Propellant Plant set up by the Chemical Engineering Division of the Bhabha Atomic Research Centre has commenced production. Operating on the basis of process know-how supplied by the French Government, the plant produces a composite-type solid propellant for the two-stage Centaure sounding rockets. The Centaures incidentally are being fabricated in the Bhabha Centre under an agreement with Sud Aviation of France. In due course, the plant will also take up manufacture of indigenously-developed propellants for use in rockets designed by the Space Science and Technology Centre, Thumba.

The Centaure propellant consists of an oxidiser such as ammonium perchlorate and a polymer which acts as a fuel binder. Briefly, the whole operation of its manufacture runs along these lines.

First, the oxidizer is ground to a fine powder in a moisture-free atmosphere. Proper grinding of the compound is essential as its particle size is important in the processing of the propellant as well as in determining its rate of burning.

Hazardous Operation

After grinding, the powder is mixed with plastisol which is prepared by mixing PVC (which acts as a fuel binder) with plasticiser. To this paste of plastisol and the oxidizer are added stabilizers, burning rate catalyst, etc. The whole operation is carried out by remote control, as it is somewhat hazardous.

The propellant paste is then cast under vacuum in moulds having the same diameter as the rocket motor. A mandrel coated with an anti-sticking agent and having the configuration desired for the burning surface is then inserted and the mould is closed.

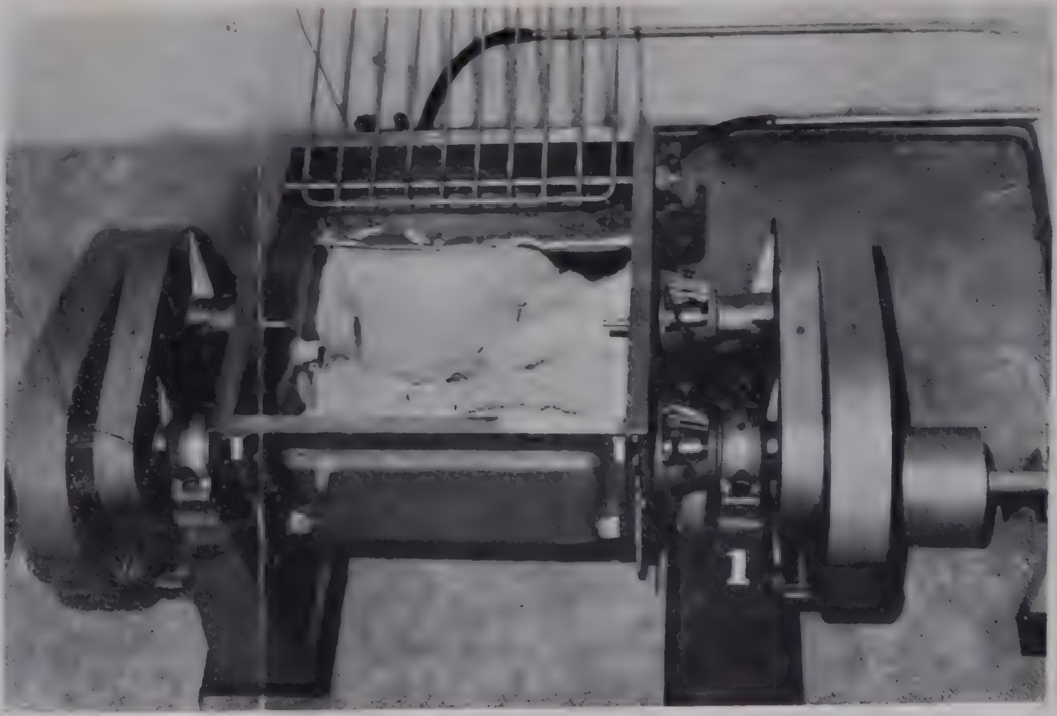
The assembly is taken to an oven and heated to about 170°C by hot air. Here, the propellant paste is converted to a solid. After allowing the assembly to cool to room temperature, the mould and the core are removed from the cured propellant and the 'grain' is cut to the required size. The 'grain' is the solid charge of fuel and oxidizer moulded to the desired configuration and size to fit the rocket motor.`

The ends of the grain are coated with an inhibiting paste which forms a solid layer when allowed to cure. This layer does not allow the grain to burn from the ends. The liner on the outside of the grain inhibits burning

(Continued on page 2)

Collection of ground ammonium perchlorate

Kneader for making propellant paste



BARC Reporting

Directorate of Radiation Protection

During August 16—September 15, 8298 radiation workers from 1031 institutions all over the country were covered by the Film Badge Service. Radiological protection surveys were conducted in five institutions outside Bombay and two within the city.

The seventh one year post-graduate training course in Radiological Physics which commenced on 16th September 1968 concluded on 15th September 1969. All the 25 persons who joined this course have successfully completed it. The trainees included four from Indonesia and one from Thailand.

Isotope Division

The sale value of radioisotopes, equipment and services rendered during August 15—September 15 totalled Rs. 1.48 lakhs. A total of 2148 consignments, including 1186 for medical use, were supplied during this period.

A total of 510 consignments of radioisotopes valued at Rs. 13,495 were exported to Argentina, Australia, Burma, Indonesia, Sweden, Thailand and Turkey.

A Gamma Chamber unit loaded with 2500 curies of Cobalt-60 was supplied to the Fertilizer Corporation of India, Sindri.

Waste Treatment Division

Air filters produced in the pilot filter production unit of the Division, were issued for use to Radiochemistry Division, Isotope Division, Atomic Fuels Division and the Rocket Propellant Plant during August.

The production cost of these filters is Rs. 4,700. The cost of equivalent imported filters would be Rs. 8,700.

Propellant Plant at Thumba

(Continued from page 1)

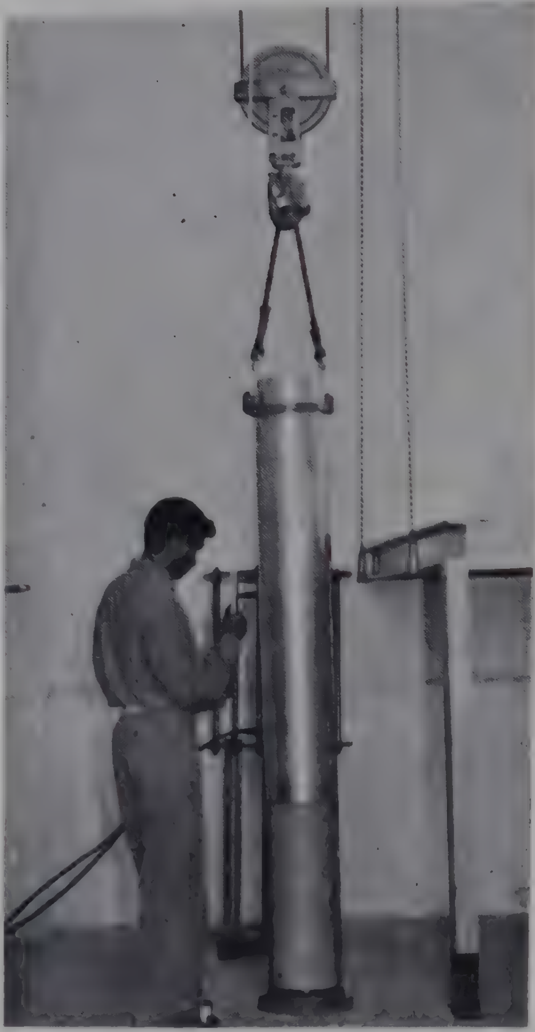
of the outside surface and also provides insulation to the motor case.

The whole process demands stringent quality control and safety measures. The propellant grain is examined visually and, sometimes, radiographically to detect cracks, air bubbles etc. Samples from the cut pieces are also checked for density and tensile strength.

Safety Features

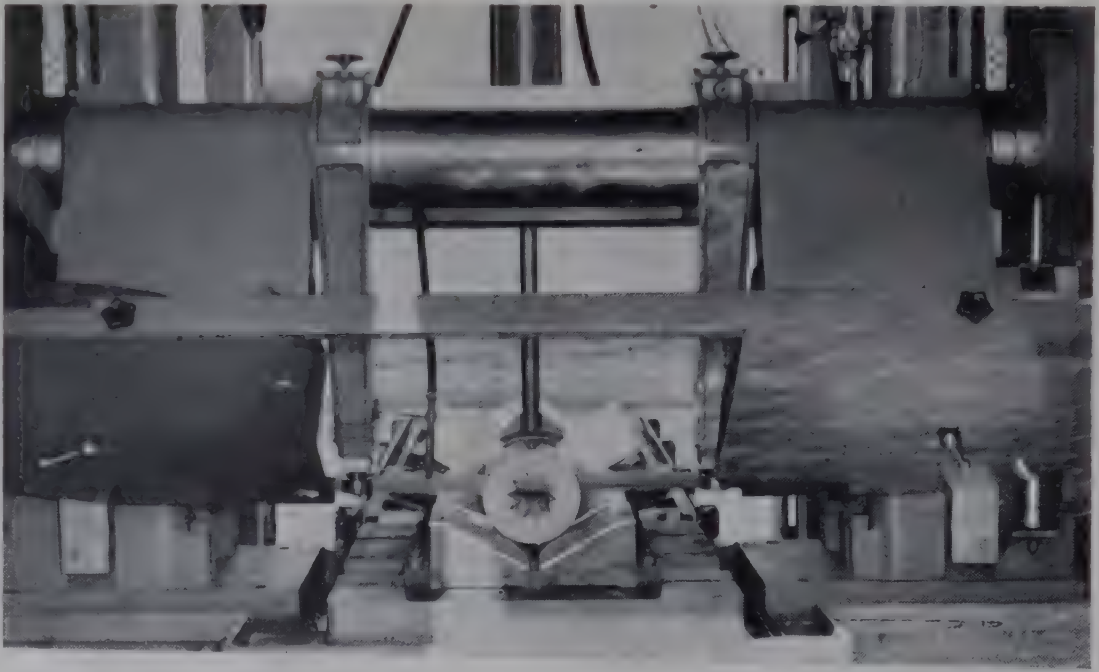
A small test grain is cast from each batch of paste for static test firing to check the ballistic performance of the propellant. Periodically, the full-sized grains are also subjected to static tests.

Since the processing of the propellant involves fire and explosion hazards, the safety of personnel and equipment has to be borne in mind when designing and operating such a plant. In this case, separate well spaced out buildings have been provided for the various operations. Some of the extremely hazardous activities are carried out behind thick concrete walls and the number of personnel for each operation is restricted to the minimum. In addition, automatic water sprinklers are installed in various buildings which operate instantaneously in case of fire. Built-in safety features also include escape doors at strategic points, lightning arresters, explosion-proof electrical fittings and earthing of all equipment to minimize effects of static electricity. ●



Removing the mould from the cured propellant

Sawing of the grain



THE EMERGENCE OF BIOENGINEERING

by

Dr. A. Sreenivasan

Head, Biochemistry and Food Technology Division, Bhabha Atomic Research Centre.

Talk given at a Seminar on Biochemical Engineering at the Indian Institute of Chemical Engineers, Bombay, on September 6.

In the last few decades, there has been a phenomenal growth of knowledge in diverse scientific disciplines as well as in the development of technological processes. So much so, there has been an extreme degree of specialisation on the part of the research investigator who tends, therefore, to work somewhat in isolation. Nevertheless, there is general recognition of the need for coupling between research and development or, if I may say so, between science and technology, so that there is an aggressive logical development from scientific discoveries to practical applications. Technologists have indeed comprehended the value of this interface between science and technology to provide a sustaining base for innovation. The dialogue between the applied biologist and the chemical engineer is one such interaction that has resulted in the emergence of the vigorous hybrid discipline of biochemical engineering.

I believe that bioengineering came into its own, as an effective interdisciplinary approach, towards the end of the Second World War when penicillin fermentation was made an engineering accomplishment. Man, however, was well aware of fermentation long before the birth of microbiology as a science. Traditional processes like cheese-making, soya sauces, fermented milk and yoghurt, leavened bread, fruit juice fermentations resulting in wine and vinegar, have all been known almost as long as agriculture itself. During the middle ages, man learned how to improve the taste of wine, bread, beer and cheese. Yet, it was thousands of years before man realised that in fermentation, he was dealing with forms of life or micro-organisms.

Expanded Knowledge

The knowledge of how micro-organisms could bring about enormous chemical transformations has vastly expanded since Pasteur's time. Microbes are in fact chemical factories. They can execute a multitude of chemical changes with an efficiency and speed that cannot be rivalled by the chemist in his laboratory. Chemical reactions in them are carried out in closely controlled sequences catalyzed by enzymes. Great strides have been made in recent years on how chemical control in micro-organisms is accomplished, and what transmits this information from mother to daughter cells.

Success Story

In fact, the culturing of a micro-organism is both an art and a science. The sensitivity with which a microbe reacts to its environment, physical and cultural, is something that has been understood to perfection by the Japanese. It is not surprising, therefore, that several of the successful industrial microbiological processes have been evolved in that country.

Recent accomplishments in biochemistry and genetics have brought man to a stage where he can predict and direct the course of chemical transformations brought about by these living cells. Thus, he can isolate suitable microbial strains to perform desired tasks and can also tailor micro-organisms by adaptations, mutations, recombinations and screening. An applied microbiologist, with judicious use of tailored micro-organisms and intelligent choice of environmental conditions, can harness Nature's cellular controls to maximum advantage. The success story of bioengineering in the fermentation industry is attributable to the appreciation at the engineers level of the biochemical capacity of microbial cells.

The inheritors of Pasteur's knowledge have, therefore, been the biochemist or microbiologist and the chemical engineer, alike. They together, soon established the successful development of a variety of fermentation processes: baker's yeast, alcohol, acetone, citric acid and several other industrial chemicals like butanol, acetic acid, oxalic acid, gluconic acid and fumaric acid. After the development of mass production of penicillin in submerged cultures, processes for other antibiotics were quick to follow.

Progress in fermentation technology is continuing. Each year, new products are added to the list of compounds derived from fermentations. Several vitamins are now produced routinely by fermentation processes. Some of the more interesting fermentation processes are the specific dehydrogenations and hydroxylations of the steroid nucleus. These microbiological transformations are economical short-cuts used in the manufacture of cortisone and its derivatives. Fermentative synthesis of the amino acids, L-lysine and L-glutamic acid are also being carried out commercially. Important agricultural uses are being found for the new fermentation product, gibberellin, a plant growth regulator. And, bacterial spores are being used as specific insecticides in another agricultural application. Microbial attack of crude oil promises to be an important source of feed materials.

Engineer's Contribution

The biochemical engineer has undoubtedly played a remarkable role in the development of modern fermentation processes. Prior to penicillin fermentation, pure-culture requirements of fermentation processes were not strictly controlled. The engineer thus encountered a formidable problem—the maintenance of aseptic conditions. Many fermentation plants were delayed in recycling their maximum productive capacities because of contamination problems. Perhaps the most notable contribution the engineer made was in the advancement of sterile techniques in the design and operation of the fer-

(Continued on next page)

Microbes are, in fact, chemical factories. They can execute a multitude of changes with an efficiency and speed that cannot be rivalled by the chemist in his laboratory.

mentors. To accomplish this, the engineer changed methods of vessel fabrication, revised gasketing, piping, and valve-designs and devised new methods of steam-sealing possible points of contaminant entry.

In addition to designing aseptic fermentation operations, the engineer also had to design air-compression and delivery systems and efficient methods for agitation and aeration. Numerous problems hitherto not encountered also faced the engineer in product recovery. Special isolation techniques involving filtration, extraction, adsorption and concentration were developed to recover small quantities of fermentation products in remarkably good yields.

All-Embracing

The laboratory scientist — the microbiologist, the biochemist and the microbial geneticist — continue to discover and advance desirable interactions between micro-organisms and their environment; the biochemical engineer controls these interactions and translates laboratory results to production-scale operation in an economic manner.

While biochemical engineering has rightly played an important role in the fermentation industry, there is awareness that it is not something confined only to industrial microbiology. It is in fact all embracing in its application of engineering practices and of all unit operations to the needs of biological systems in processing procedures.

Food preservation operations such as pasteurisation, sterilisation, freezing and drying, require an intimate knowledge of biochemical properties of foods that are to be processed and of micro-organisms that they harbour. The canned food industry applies the principle that perishable foods can be preserved through proper application of a heat process. Progress in canning has been continuous since the time it was discovered that food could be preserved if it were placed in a sealed container and heated. Today's canning plants are efficient, industrial operations where a single line may produce several hundred containers per minute of wholesome, nutritious food. Research that has gone into heat resistance of food-borne organisms, rate of heat penetration in food products, sanitation, etc., has resulted in greater economy in food canning.

The dairy and milk-producing industries are concerned with the collection, processing and distribution of milk and its products. Extensive research work on the preservation and processing of this perishable commodity has led to the evolution of a specialised technology. The important consideration underlying developments in dairy industry has been the evaluation of the role of heat transmission in dairy products and the design and fabrication of machinery to effectively adopt the principles of dairy technology.

Oldest Form

Drying is probably the oldest form of food preservation. Over the years, dehydration methods have improved the acceptability of standard dried products such as dried milk, dried eggs, fruit juice powders, dehydrated fruits, vegetables, sea foods, meat and so forth. Continuous research and development has been mainly responsible for improved reconstitution of dried products, increased storage stability and efficient production. Operations such as spray drying, instant spray drying or agglomerated instant process, puff drying, foam-mat drying, osmotic dehydration, freezing concentration, gelatin—or other protective coating —drying, etc. are developments that have resulted from feed back problems of the food industry, calling for preservation of labile qualities such as flavour, texture, reconstitution property, colour, nutritive value, prevention of oxidative changes and so forth. These are, in fact, interactions of knowledge and information gained from the physics and engineering of drying as a unit operation on the one hand and the biochemical changes occurring during the preparation, dehydration and subsequent storage, on the other.

Rapid Growth

Freezing of foods and other biological materials is an important commercial activity where the biochemist has made significant contributions. A great variety of foods is frozen commercially. Three decades ago, frozen foods were considered to be of poor quality. The acceptability of frozen foods commercially available today is very high. A study of production statistics shows that the frozen food industry has grown with great rapidity during the past 30 years. Freezing preservation has greater advantages than other processes of food preservation since it preserves almost indefinitely the quality, the taste and the vitamin content of the food. The problems that might arise in cooling and freezing of foodstuffs are many. Foods have different sizes and shapes and are generally poor conductors of heat. Some of the drawbacks inherent in freezing procedures have been eliminated because of continuous research and development. Quick-freezing, the newer method of freezing, has now been found to be superior over slow freezing since it preserves cellular structure of foods and also prevents growth of micro-organisms during freezing.

A very recent noteworthy development for which unstinted credit must

(Continued on page 5)

Recent accomplishments in biochemistry and genetics have brought man to a stage where he can predict and direct the course of chemical transformations brought about by these living cells. An applied microbiologist can harness Nature's cellular controls to maximum advantage.

Air Filters from Trombay

ATMOSPHERIC pollution is almost a built-in side effect of industrial activity. The air we breath has of course never been free from harmful particles but, during this century, so much has been injected into it that at many places, pollution has reached saturation point. Added to this, within these twenty-five years, one more source of pollution, atomic energy, has appeared on the scene lending greater urgency to the problem with its dreaded hazard of radioactivity.

Atmospheric pollution around industrial areas is mostly because of bacteria, mineral dust, harmful chemicals, radioisotopes and ordinary earth dust. While, in atomic plants and labs, the need is more to prevent radioactive particles from escaping into the air outside, in a great many industries, particularly those engaged in the production of pharmaceuticals, chemicals, electronics etc. there is as much need to screen incoming air. In the pharmaceutical and antibiotic industries for instance, many chemical reactions are brought about by some particular types of bacteria. Thus, except those required, all other types of bacteria must be kept out. Another instance is that of plants manufacturing delicate precision instruments and components such as wrist watches, electronic instruments etc. where a high degree of tolerance among parts is required. Fine, hard dust particles getting into such pieces can disturb the delicate balance among parts.

Main Objective

Among the devices used to reduce exhaust of harmful particles or to prevent their entering the premises, is the air filter. Filters range from simple guaze-like structures to fine interlayed ones for removing infinitesmally small particles from air. In the case of atomic energy, very high efficiency filters, having an efficiency of the order of nearly 99.97 per cent for all submicron particles are needed. The main objective in this area is to ensure that radioactivity is not released into the atmosphere.

High efficiency air filters are made from fine fibrous materials such as micro glass, asbestos, cellulose etc. When a particle enters the filter, it has to follow a tortuous path through a bed of fibres. Somewhere along the way, the particle sticks to the fibres and gets caught.

As part of its research and development work on management of radioactive gaseous wastes, the Waste Treatment Division of the Bhabha Atomic Research Centre has been working on developing suitable air filters for atomic plants and labs. After six years of investigations, it has successfully developed filters of very high efficiency called "absolute filters". A pilot plant at the Division set up primarily to study engineering and quality control aspects for large scale production is now meeting most of the internal demands of the Centre.

Semi-skilled Labour

Experience at the Bhabha Centre has shown that good quality filters can be made by local craftsmen with necessary training as the skill required is somewhat similar to that demanded by traditional crafts.

Once the development work is completed, and the manufacture of each component of the filter is standardized, its fabrication can be undertaken by such semi-skilled personnel. The major operations mainly include sheet metal work, carpentary work, pasting and shaping of delicate papers. Production of filter medium and testing of the filters is however a highly specialized job which requires supervision by qualified people.

The Waste Treatment Division of the Bhabha Centre is undertaking a systematic study to find out the performance of its filters in nuclear, electronics, textile. tele-communication and pharmaceutical installations. The data obtained so far has indicated

(Continued on page 7)

Bioengineering

(Continued from page 4)

go to the chemical engineer is the production of textured vegetable proteins which can be made to resemble any type of flesh food, with suitable processing variables and addition of flavouring ingredients.

Industrial fields, other than fermentations and food processing, which are concerned with biological sciences are many. Thus, biochemical engineering principles are applied in the manufacture of sera and vaccines, in extraction processes for hormones and in the manufacture of bone products such as glue and gelatin. A great deal of research has also gone into treatment of sewage and industrial effluents. Quite a few processes have employed industrial enzymes.

Cause of Success

I have attempted to highlight some of the diverse applications of biochemical engineering. In giving this somewhat cursory survey of bioengineering problems and achievements, I am conscious that I have perhaps sought to emphasis the obvious.

What I do wish to state here is that much of the success that the food industry has achieved—and this, as you know, is the number one industry in the U.S.A.—has been due to the cross fertilization of ideas and needs between the biochemist and the chemical engineer. Wherever an innovation is product—or process—oriented, it should be discerned as a complex feed-back type of effort which successfully integrates engineering principles and practices with product quality. ●

NUCLEAR INDIA

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While intimating change of adress, the code and number given on the wrapper should be mentioned.

News From IAEA

Surveying the Present State of Nuclear Power

Following a three-year avalanche of orders for nuclear power stations up to 1968, there is now a comparative lull. This is enabling utilities to assess early experience with the new generation of large commercial power plants and also providing an overloaded industry to increase its capacity. A prediction that expansion will continue was made by Professor Ivan Zheludev, of the International Atomic Energy Agency recently.

By 1975, he said, more than 300 nuclear power stations are expected to be in operation throughout the world with a total capacity of 1,50,000 megawatts against 20,000 at present. The forecast for 1980 remained at more than 320,000 megawatts of installed nuclear power.

As Deputy Director General for Technical Operations, and representing the Director General, Dr. Sigvard Eklund, Dr. Zheludev was inaugurating a survey course on the technical and economic aspects of nuclear power as well as regulatory questions. Held at Vienna during 4-12 September the course was aimed at assisting the planning and implementation of nuclear programmes, particularly in developing countries.

Professor Zheludev said that because the rate of growth of nuclear power in developing countries was very slow and would represent only about three per cent of the world's capacity in 1975, the IAEA was endeavouring to promote knowledge and encourage applications in such countries.

Keeping Radiation Away From the Patient

There have been "almost explosive" developments in certain nuclear techniques for medicine which can be performed entirely in the laboratory and do not involve the administration of radioactive materials to patients. They have led to the development of important new methods for the diagnosis and investigation of disease.

This was stated by Dr. Andre Finkelstein, IAEA Deputy Director General for Research and Isotopes at the opening of a meeting called by the International Atomic Energy Agency (IAEA) and the World Health Organisation (WHO) at Vienna during Sept. 9-12 to discuss "In Vitro Procedures with Radioisotopes in Clinical Medicine and Research".

More than two hundred specialists in medical work, and in the use of radioisotopes, coming from nearly thirty countries and three international organizations, attended.

Dr. Finkelstein said that activities relating to medical applications of radioisotopes formed only part of the activities of IAEA but were important, particularly for developing countries. The procedures discussed offered many advantages in terms of simplicity, high sensitivity and low cost. They could in most cases be performed in small medical radioisotope laboratories with relatively simple apparatus. They did not expose the patient to any radiation hazard, nor indeed, require the participation of the patient at all. They were thus particularly suitable for use in localities where facilities were limited or where field studies had to be undertaken.

"Advances in these procedures in recent years have been almost explosive" observed Dr. Finkelstein. "Much remains to be done, however, especially in their standardization, before they can be fully accepted in routine practice. Standardization is an aim in which the IAEA has a particular interest.

Standardizing Radioisotope Methods For Diagnosing Blood Diseases

At the invitation of the International Atomic Energy Agency (IAEA), the Panel on Isotope Procedures in Diagnostic Haematology — a subsection of the International Committee for Standardization in Haematology—held one of its meetings at IAEA headquarters, Vienna, during August 25-28. During the four-day meeting, the Panel reached agreement on certain methods of diagnosing blood diseases by means of radioisotopes. Representatives of the IAEA and the World Health Organization (WHO) also attended the meeting.

The extent of the experts' agreement marked a definite step towards the formulation of world-wide standards to guide physicians in the use of radioisotopes in the field of haematology. Six years ago, a similar meeting sponsored by the IAEA and attended by five participants of this meeting as well as others, failed to come to an accord.

Labelled Blood

The radioisotope, chromium 51, can be used to determine the life span of red blood cells, an invaluable help in diagnosing the cause of unexplained anaemia. A sample of blood taken from the patient is "labelled" with chromium-51 and reinjected. The labelled cells can subsequently be detected in the blood throughout their lifespan in normal persons about 115 days.

A compound of phosphorus and fluorine known as DFP, when labelled with radioactive forms of phosphorus, carbon or hydrogen, can be similarly employed. DFP is administered directly by intravenous or intramuscular injection.

Though the use of chromium-51 and DFP in haematology has been known for a number of years, the methods used in different laboratories have differed widely. The Panel reached agreement on standard techniques for labelling red cells with chromium-51. It also agreed on methods of studying red cells survival with both chromium-51 and labelled DFP, and of presenting and analysing the resulting data. ●

Molecular Biology Can Help Medicine

X-ray diffraction is a technique in which beams of X-rays fired through crystals produce images from which the structure of a crystal can be exactly calculated. It is now enabling molecular biologists to build perfect 3-dimensional models of the giant molecules found in living systems, with every atom in the right place. Computers have cut down the time taken to work out the extremely complex calculations which are needed to interpret the X-ray pictures. For this reason, the rate at which molecular biologists are announcing 3-dimensional models of new molecules is steadily increasing and these models are now beginning to become valuable to practical medicine as well as to theoretical science.

FOR more than twenty years, Dr. Max Perutz, Director of the Molecular Biology Laboratory at Cambridge, has been working on the structure of the highly complex protein molecule of haemoglobin, the red coloured compound found in all red blood cells, which is responsible for picking up oxygen from our lungs and carrying it round the body in the blood stream to every living cell. The oxygen is used in the cell to produce energy by burning food-materials. In 1968, Dr. Perutz announced that his 3-D model of haemoglobin was complete.

As with other "working" molecules, the structure of haemoglobin is related to its function. Each molecule is protected from reacting chemically with water in the blood by a hydrophobic coating. The model is also providing a new understanding of how the vital part, the small area which actually picks up and carries oxygen, within the molecule, forms its temporary link to the oxygen. As Dr Perutz said himself, the evidence of the last twenty years has really "only provided an understanding of *anatomy* at the molecular level. Now it is necessary to advance to the physiology."

Haemoglobin Model

Dr. Perutz chose haemoglobin initially, not just for its theoretical interest, but because it seemed likely to prove a valuable molecule to study for medical reasons. Doctors have known for some years that there are nearly one hundred mutant forms of haemoglobin, some relatively harmless, some which cause severe and often incurable illness, each due to a different and often very slight abnormality in the 3-dimensional structure of the molecules. Dr. Perutz has suggested, in a recent report, that his now complete model of haemoglobin opens up the possibility of studying the part played by the pieces of the molecule which are different, or missing, in each mutant. In his report, Dr Perutz provides a massive table linking medical symptoms, such as anaemia or cyanosis, with various known haemoglobin mutants and with the precise nature of these mutants at the atomic level. He then goes on to consider how defective or abnormal haemoglobin might be repaired.

Transplantation

In these considerations, Dr. Perutz moves into realms which only a few years ago would have been considered as science fiction. But there is no one better qualified to make it clear that fiction is fast becoming fact. Some way in the future lies the possibility of implanting new genetic material into someone possessing faulty haemoglobin. Faulty haemoglobin is due to faulty genetic material. Recent research has shown that a harmless virus can be used to carry new genetic material into various parts of a body. It may become possible to use such a "ferrying" virus to transport the correct genetic code for correct haemoglobin structure, either artificially synthesised or removed harmlessly from someone else's body into the spleen and bone marrow, where new red blood cells are made. Dr. Perutz describes this idea as "imaginable but still Utopian." But, as he goes on to say, "a less remote possibility might be the replacement of the organ producing the abnormal haemoglobin."

This type of transplant, involving the replacement of faulty spleen or bone marrow—or both—with tissue taken from a dead or living person, should not raise fundamentally greater problems than any other transplant operation and may well become commonplace, once the problems of rejection have been overcome, as surgeons forecast they will be within a few years. Bone-marrow transplants have already been used to treat the victims of radiation sickness. Meanwhile, the most immediate attack upon the abnormal haemoglobins and the diseases they cause should, says Dr. Perutz, be to try to eliminate them from the population by genetic analysis and warnings to couples likely to produce children suffering from the more severe diseases, such as the worst forms of anaemia.

This work on haemoglobin is one of the earlier examples of a whole wave of benefits to medicine which will be brought about through the new understanding molecular biology has given us of body processes at atomic level. (Reprinted from SPECTRUM No. 57, 1969). ●

Air Filters from Trombay

(Continued from page 5)

that the filters which were initially developed for use in the nuclear systems are equally useful in other industries. It is estimated that the total requirement of industries is many times more than that of nuclear plants and laboratories of the Department of Atomic Energy. Once these studies are completed, it will be possible to prepare plans for production of high efficiency filters to meet the requirements of all the industries in the entire country. ●

A NEW TOOL FOR A NEW AGE

THE RADIOACTIVE ISOTOPE

A radioisotope processing plant

Fabrication of intense radiation sources

In the understanding, prevention and treatment of diseases, in the development of improved agricultural methods, and better methods of insect and pest control, for more efficient process control in industry, and in harnessing ground water resources, the use of radioactive isotopes has resulted in spectacular advances.

Since 1959, the Isotope Division of the Bhabha Atomic Research Centre, has been supplying a wide range of radioactive products within the country and abroad.

These products include :

● Primary Isotopes ● Radiopharmaceuticals ● Labelled Fertilizers & Insecticides ● Radiation Sources, Neutron Sources ● Cobalt-60 Teletherapy Sources ● Gamma Chambers ● Industrial Radiography Equipment ● Labelled Compounds ● Radiochemicals and ● Self-Luminous Sources.

In addition BARC offers

● Isotope Radiography Service ● Training in Isotope Radiography ● Training in Use of Radioisotopes and ● Assistance in setting up Isotope Laboratories

By adhering to the highest standards of manufacture and quality control, Isotope Division, BARC, has built up an enviable record for dependable preparations. Quick delivery, competitive pricing, and generous allowance for in-transit decay are additional attractive features of our service.

Isotope Division has a dynamic development programme to extend the already wide range of products and make available newer radiopharmaceuticals, radiochemicals, labelled compounds and radiation sources.

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NUCLEAR INDIA

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THE MOONLANDERS IN BOMBAY. At the Tata Institute of Fundamental Research, Bombay, Indian scientists played host on October 26, to the three American astronauts who made history in July. Here the Commander of the Lunar Expedition, Neil Armstrong presents a photograph of the Lunar Module over the Moon to Dr. Vikram A. Sarabhai, Chairman of the Atomic Energy Commission. On the right foreground is a carved wood elephant presented to the Astronauts by Dr. Sarabhai. Astronaut Michael Collins is seen at right.

Trombay Seminar on Mutation Breeding

THE Bhabha Atomic Research Centre since its inception has been playing a vital role in developing radiation facilities and extending them for studies in fundamental aspects of radiobiology and crop improvement. To increase exchange of scientific information, and promote personal contacts in this area, the Food and Agriculture Committee of the Department of Atomic Energy organized a symposium on "Radiations and Radiomimetic Substances in Mutation Breeding", at the Bhabha Centre during September 26-29 in which over 80 scientists from research institutions and universities in India, and six delegates from Ceylon, Guyana, IAEA, Japan, Phillipines and Taiwan participated.

Inaugurating the symposium, Shri H. N. Sethna, Director of the Centre, said that in these rapidly changing times, it was essential to evolve new concepts and methods, leaving behind those that are obsolete and do not fit in with the country's economic conditions. The principle, he said applied particularly to Indian agriculture.

The following is an excerpt from his

(Continued on page 2)

Labelled Fertilizers, Insecticides from BARC

An increasing number of agricultural research institutions in the country are using radioisotopes and labelled compounds for improving agricultural methods and controlling pests. To meet the varied needs of the institutions, the Isotope Division of the Bhabha Atomic Research Centre has added to its range of preparations for use in this area. Among them are fertilizers such as superphosphate, triple superphosphate, nitrophosphate and mixed fertilizers labelled with radioisotopes. Since research investigations using these as tracers have provided valuable data about optimum fertilizer intake in different soils at different stages of plant growth, more and more agricultural institutions are finding them useful for their research work.

Besides fertilizers, a number of insecticides have also been labelled with radioisotopes for helping in the study of their action on pests. For instance, Malathion, an insecticide commonly used in India for pest control has been labelled with radiophosphorus. Using this labelled product, one can obtain valuable data on the mode of action of the insecticide and the development of resistance by some tropical pests. The Isotope Division of the Bhabha Centre has a group working on developing a number of labelled agrochemicals, weedicides and insecticides. Besides meeting internal demands, the Centre has in recent months exported some of its products in this area. ●

BARC Reporting

Spectroscopy Division

A spectrographic method has been developed for the estimation of gadolinium, dysprosium, terbium, helmium and erbium in yttrium oxide of purity better than 95%. D.C. arc excitation was employed and the spectrum recorded in the region 2400 to 3300 Å on Ilford N-30 emulsion. The concentration range covered for each of the impurities is 0.1 to 1.0%. The precision of the method is about 10%.

Isotope Division

A total of 117 consignments of radioisotopes valued at Rs. 11,436|- were exported to Australia, Burma, France, Ghana, Hungary, Indonesia, Morocco, Romania, Sweden and Thailand during Sept.-Oct. Mention may be made of export of phosphorus-32 labelled triple superphosphate to Morocco, Romania and Hungary against orders received from the International Atomic Energy Agency, Vienna.

* * *

Discharge measurements in Tons river near Dehra Dun were carried out using tritium and bromine-82 radiotracers. These experiments have provided information on the nature and characteristics of mixing pattern in turbulent rivers flowing in mountainous regions.

Electronics Division

A panoramic exposure dose assembly has been designed and fabricated for accurate inter-comparisons and routine calibration of dose meters, which are used for personal protection and environmental survey in radiation areas.

The system is safe, automatic and remotely controlled. It has an accuracy of ± 3% for calibration of dosemeters.

A two-week programme of lectures and demonstrations in food irradiation for scientists from South East Asian countries commenced at the Food Irradiation and Processing Laboratory of the Bhabha Atomic Research Centre, Trombay, on October 27. The visit of the scientists was arranged under the UNDP Technical Assistance Programme of IAEA. Here, a Trombay scientist explains the working of a vacuum double seamer to the visitors.

"Radiations and Mutagens Not the only Panacea"

(Continued from page 1)

inaugural address:

"Radiations and radiomimetic substances have been widely recognised as important tools for inducing genetic variability and crop improvement. The cardinal issue to-day is not whether these physical and chemical agents can induce useful mutations but whether crop improvement can be brought about in economical and effective ways. Quite naturally comparisons are made by the results obtained by conventional methods and radiations or chemical mutagens. This controversy appears to me an exercise in futility. Before the genetic effects of radiations or chemicals were discovered, the methods available for us were: introduction, selection and hybridisation. The question whether introduction or selection is superior to hybridisation did not engage the plant breeders in a futile controversy. Mutation breeding too is one such approach complementary to all the conventional methods. The problem then on the effectiveness of this method can be solved not by academic discussions but by a more vigorous approach to the problem in crop plants. The statistics collected by the International Atomic Energy Agency on the mutants released in crop plants indicate the effectiveness of this method and an ascendancy of the mutants released for cultivation during the last few years.

Water Potential

"Rightly, radiations and chemical mutagens are not the only panacea for all the ills facing Indian agriculture. Concomitant development and exploitation of the water potential, both surface and underground, fertilisers, pesticides, fungicides and breeding new varieties are essential. Fortuitously, the dwarf varieties evolved in Mexico were easily adopted here and brought about a revolution in wheat production in the Punjab, U.P. and contiguous areas. Although the impact of introduced varieties of rice is not felt to the same extent, it has revolutionised our concepts and approaches to rice breeding. In a similar way, the availability of male sterile lines in jowar and bajra and the exploitation of hybrid vigour in maize have paved the way for attaining high yields. The productivity of large number of crops and horticultural, vegetable, oilseed, fibre crops

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Development of Electronics at the Bhabha Atomic Research Centre

by

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the world has witnessed significant progress in a wide variety of disciplines. Two fields which have distinguished themselves among them are the nuclear and space sciences. The most important factor that has contributed to the accelerated progress of these disciplines is electronics. More than any other discipline, electronics has enabled man not only to probe into the unknown and vast expanses of infinite space, but also into the equally uncharted and infinitesimal regions of the atom.

Electronics began as a systematic technology early this century with the invention of the radio valve. Using the amplifying capabilities of the radio valve, radiocommunication was developed for world-wide application in 1922. Broadcasting soon became a reality. It was gradually possible to control the cost and quality of broadcasting systems very closely, and by the Thirties, though still encompassing only radio technology, electronics became a dependable and well-understood science.

Development of Transducers

Inventors were quite early to recognize that with electronics one could do things which were otherwise impossible. Using the known properties of radiowaves, magnetic fields, and light sensitive materials, many useful applications of electronics in measurement, controls and processing were developed. They also developed 'transducers', which transform values of temperature, pressure, etc., into small electrical voltages. The technique of television was also developed to an advanced stage in the same decade. The use of electronics in nuclear research started around the same time. Thus it became evident that the potential of electronics was limitless and provided an area where inventors, scientists, engineers, and manufacturers could find infinite scope for putting in fruitful efforts.

This was the state of development when the Second World War broke out. The course of the war soon made it clear that technology was to play a major role in deciding its outcome. Owing to the impetus given by the war, electronics soon grew from its position of a very young and new science into a giant industry. New applications of electronics in communications, control, armaments and the well-known radar were developed speedily, and electronic equipment worth thousands of crores of rupees was made for the armed services. In fact, the Second World War, with the growth that it provided, created the modern version of electronics as we recognize it today — a vital branch of modern technology in its own right. Soon after the war, these great inventions were applied for the benefit of industry and the home. Industrial heating, automatic control, television, computers and lasers are only a few examples of this. Electronics has opened up radically new methods of communication with the use of satellites and lasers. The use of satellites, apart from greatly increasing the number of channels for long distance communication, has made global television possible for the first time. The development and assimilation of electronic methods was very rapid and advances in almost all areas of science and technology became dependent on electronics in a critical manner. The development of atomic energy in its present form would have been impossible but for the many contributions of electronics, particularly in radiation measurements and in control systems for nuclear reactors and ancillary plants. Electronics has changed the entire character of military operations, so much so that a good portion of defence expenditure of the developed countries is on the production of electronic equipment. Electronics has thus come to play an ever increasing role in research, defence, industry agriculture, medicine and even in day-to-day household work.

It is, therefore, not surprising that most developed countries have spared no pains to nurture the growth of electronics. In almost all developed countries, electronics, along with its ancillary industries, accounts for a major portion of the investments.

That a developing country can leap-frog into sophisticated modern technologies, without the requisite industrial base, has been established by India during the past ten years, in the field of atomic energy and, to a certain extent, in the field of space technology. Part of this success can be attributed to the considerable amount of research and development effort in electronics that was concentrated on (a) the development of basic materials for the production of modern electronic components; (b) the development of the components themselves; and (c) the design and development of highly refined electronic instruments and equipment.

State of the Industry

At this juncture it would be relevant to consider, in some detail, the present state of affairs in respect of the electronics industry in this country. This industry is still very much in its infancy and the work now being done, with some exceptions, consists mostly of assembly work and/or production, based on collaboration with foreign firms. It was only in recent years that the manufacture of radio receivers, line-communication equipment, nuclear electronic instruments and, in a very small way, radar equipment was undertaken. Though in the case of radio receivers, line-communication equipment and nuclear electronic instruments, the in-

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* Condensed from a dissertation presented by Shri Rao on the occasion of the presentation to him of the S. S. Bhatnagar Memorial Award for Engineering Sciences, on July 28, 1969 at New Delhi.

atomic energy and food

International activities aimed at improving, increasing and conserving food supplies are fostered in special ways by the Joint Division of Atomic Energy in Food and Agriculture established by the IAEA and the Food and Agriculture Organization of the United Nations. An examination of the processes by which food is produced and of the skills arising from nuclear techniques which are being applied is made here by Maurice Fried and Bjorn Sigurbjornsson. They are the Director and Deputy Director of the Joint Division, which is an integral part of both the Agriculture Department of FAO and of the Agency's Department of Research and Isotopes.

FROM a technical standpoint food and agriculture means controlled transformation of inorganic matter, into organic matter, which in turn is transformed into food products that must be preserved until they reach the consumer.

The basis for food production and, indeed, for all life on earth, is the utilization of sunlight by green plants to combine water and carbon dioxide to form organic molecules of sugar, a process known as photo-synthesis. All other forms of organic matter are derived from the photo-synthetic product. In addition to sunlight, water, and carbon dioxide, the green plant needs a variety of inorganic nutrients to grow and to manufacture the various amino acids, proteins, fats and other sugars. The plants, like all other organisms, also need energy to sustain their various chemical reactions and derive this energy from the oxidation of organic compounds through a normal process of respiration.

Put in terms of energy the green plants capture the energy of the sun, thus raising their energy level and enabling them to create food products which man then uses as a source of energy to maintain life.

Plant products can, of course, provide foodstuffs directly in the form of grain, fruits and vegetables, or they can be converted into livestock products of fish. Food, whether plant or animal, is seldom consumed immediately but must be preserved and transported until available to a consumer. It is thus clear that food and agriculture really implies a long series of complex physical and chemical steps and commercial transactions, all of which are important.

Varied Technology

The efficiency of food production depends chiefly on three factors: plants and animals must be provided with enough of the proper nutrients; they must have the appropriate genetic make-up to make efficient use of the nutrients; and lastly, they must be protected against damage and deterioration both while growing and while stored as food products. In short, efficient agriculture must ensure proper feeding, proper breeding and adequate protection.

In order to achieve efficient provision of food, one must apply a varied technology at all steps along the way from the inorganic molecules to the finished product on the consumer's table. It requires a thorough understanding of all the physical, chemical and biological factors involved and the application of science and technology to the production processes themselves.

One may ask how nuclear techniques enter into this picture. The fact is that for this work one needs to apply all known technological skills. Nuclear techniques form a part of man's skills, and in the short period since the dawn of the Nuclear Age it has become clear that isotopes and radiation represent unique and often indispensable means of studying and promoting food production and preservation at every level of the process. Examples of applications of nuclear techniques, and the work of the Joint FAO/IAEA Division of Atomic Energy in Food and Agriculture including its promotion of international co-ordination of these applications are described in this article.

Soil and Water

The problem of feeding plants primarily deals with making adequate nutrients available and providing enough water.

The three nutrients most commonly lacking in adequate supply are nitrogen, phosphorous and potassium, though calcium, sulphur, magnesium and a number of nutrients required in lesser amounts may also be lacking under a given set of circumstances. Soils provide these constituents naturally in variable quantities and therefore differ in fertility. However, in order to achieve peak performance of a plant, one must usually add nutrients to the soil in the form of fertilizers.

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Independent Course in Electronics

(Continued from page 3)

digenous designs are reasonably up-to-date, the design philosophy of radio-communication equipment and radar now being produced in the country is at least ten years out of date. Even the radio receivers, which account for a large fraction of India's electronics production effort, are not yet completely indigenous. The manufacture of the components again is done mostly on the basis of foreign knowhow and almost always with foreign collaboration. All this indicates that in the field of electronic components production, much ground remains to be covered. Most of the components of high specifications required for sophisticated electronic equipment, with a few notable exceptions, are yet to be indigenously developed and manufactured. In the case of instruments and more sophisticated units, most of the components as well as the know-how have, at present, to be imported. Thus, apart from the continuing drain on foreign exchange in the form of payment for components and sub-assemblies, there is a further continuing drain in the form of royalties to be paid for know-how, which is imported. Such a state of affairs does not generate an atmosphere suitable for hard-nosed research and development which could profitably lead to indigenous know-how. Under these conditions a state of perpetual indebtedness in respect of know-how results and we are in the unenviable position of relying on foreign sources for even those concepts in the design of electronic equipment and components, which are already well established and are a few years old.

Beginnings at BARC

In realization of all these pitfalls, the Bhabha Atomic Research Centre at Trombay decided to chart an independent course for itself, in the field of nuclear electronic instruments, electronic components and systems design and development. Right from the year 1952, when a small unit consisting of a handful of electronic engineers and technicians was formed by the late Dr. H. J. Bhabha, as the nucleus towards the accomplishment of this objective, the prime guiding motive has been one of self-reliance. The ultimate aim of the exercise was to develop an independent electronic industry in which the design and fabrication of sophisticated electronic instruments and components would be done entirely on the basis of indigenous effort and know-how. Since making a modest start in 1952, this programme has grown steadily, both in size and in the range of activities covered.

Apsara Control System

In parallel with this, another group was established in 1953, with responsibility to design, develop, fabricate, install and commission the entire control system of a nuclear reactor along with all the electronics, and electro-mechanical instruments, sub-assemblies, ionization chambers, and counters. At that time the know-how on reactor control systems available all over the world was extremely limited. In spite of this and other difficulties, this group completed the control system for India's first nuclear reactor 'Apsara' and followed it up by assuming responsibility for the installation and commissioning of the control system for the 'Cirus' reactor. This group has also been responsibile for the entire design, construction and commissioning of the control system for the reactor 'Zerlina' and the radiation monitoring system for the plutonium plant.

Realizing the importance of the role of computers in modern technology, the Bhabha Atomic Research Centre embarked on the design, development and fabrication of computers a few years ago. Computers cover a very wide range — from simple analogue and digital computers through special purpose analogue and digital computers to the most advanced high speed general purpose computer. A number of analogue computers for special purposes, and a large size general purpose analogue computer have been designed and fabricated in the Bhabha Atomic Research Centre and are now in regular use. A medium size computer, which is intended to serve, depending upon its configuration, as a computer for real-time application, on-line data collection and reduction or scientific computation, has been designed and fabricated and is undergoing final tests.

All the sophisticated items described above have been accomplished without any foreign collaboration. The resultant accumulation of indigenous know-how has more than made up for the moderate price in foreign exchange that has had to be paid hitherto for the import of components. In order to eliminate even this drain on foreign exchange, the development of components and materials has been accorded high priority by this Centre. A number of components, such as precision high stability resistors, Zener diodes, silicon rectifiers, germanium power transistors, thermoelectric modules and coolers, metal film resistors, multi-turn potentiometers, tantalum capacitors and components for servo-instruments such as motors, resolvers, synchros and tachos have been developed and produced on a pilot plant scale.

The Electronics Committee

The achievements listed above were accomplished by groups which, while functioning as almost independent units, have still had to operate within the framework of the Bhabha Atomic Research Centre, which is primarily a research and development organization. It was felt for quite some time that the occasion was opportune to embark on a commercial venture for the large-scale expansion and diversification of all the above-mentioned activities.

In 1963, it was decided that the

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World Nuclear Round

Japan Makes Enriched Uranium

JAPAN'S Physical and Chemical Research Institute, a special corporation under the Science and Technology Agency, recently announced that it had succeeded in the test manufacture of enriched uranium from natural uranium. Enriched uranium is an indispensable nuclear fuel for atomic power generation. At present, Japan depends on the United States to fill all of its needs for enriched uranium. But the recent experimental success by the Institute may well be called the first step by Japan toward the manufacture of this vital substance.

Natural uranium is a mixture of fissionable Uranium 235 and non-fissionable Uranium 238. But it contains only 0.7 per cent of Uranium 235 with the remaining 99.3 per cent being Uranium 238. Therefore, to make uranium an efficient nuclear fuel, it is necessary to separate Uranium 235 from Uranium 238 and increase the concentration of Uranium 235.

There are two methods for enriching natural uranium: that is, the centrifugal separation method and the gaseous diffusion method.

The Physical and Chemical Research Institute adopted the latter method. Under this method, uranium is combined with florine and gasified. Then the gas is passed through a diaphragm with countless pinholes so that the Uranium 235 may be physically sifted out from Uranium 238 by taking advantage of the difference in their respective molecular weights.

The development of this special diaphragm is a key to the success of the process. The Physical and Chemical Research Institute has completed a unique diaphragm with the cooperation of the Nuclear Fuel Division of Sumitomo Electric Industries Ltd.

The diaphragm is 0.1 to 0.15 millimeters thick, made by sintering fine grains of alumina (aluminium oxide.)

It looks like a hard, silver-gray filter with a diameter of about 4 centimetres and an effective area of 13 square centimetres. The diaphragm has innumerable pinholes, each measuring several times smaller than one ten-thousandth of a millimetre across.

In the experiment, hexafluoride uranium gas, heated up to 65 degrees C, was passed through the alumina diaphragm, and this enriching process was repeated nine times. As a result, the concentration of Uranium 235 in natural uranium was raised from 0.728 per cent to 0.742 per cent. The separation efficiency of the diaphragm, as calculated from the result of the experiment, works out as high as 70.6 per cent of the theoretical maximum. This is considered a signal success by all quarters concerned.

At an actual uranium enriching plant, several thousand separation units, each including a cylindrical diaphragm and compressor, are combined to manufacture uranium fuel with a Uranium 235 content of 2 to 5%.

Magnox-type Stations Record

Britain's magnox reactor stations have built up an impressive record for reliability and capability. The seven magnox stations in the country have averaged only 3.3 hours out of action in every 5,000 operating hours.

Magnox type stations have graphite moderated, carbon dioxide-cooled reactors using natural uranium fuel elements canned in magnesium.

Proof of the magnox stations' ability to operate at high loads over their lifetime is vital, since the availability of nuclear plants becomes increasingly important as their share of a nation's electricity output grows.

In the case of Britain, nearly a quarter of her power needs is likely to be met by nuclear reactors by 1975.

The magnox stations are in fact only the first generation of nuclear plants in Britain's programme, and most of the shutdowns which have been needed in these stations have been due to conventional plant, not the reactors.

Improvements in design should largely overcome these problems in the advanced Gas-cooled Reactors which Britain is now building.

But the magnox record is still impressive. Bradwell, one of the first stations, has been on load for more than 80 per cent of its life since 1962. The other stations were working between 75 and 85 per cent of the time.

The last of the magnox stations will be at Wylfa, in Anglesey (North Wales). At 1,200 megawatts, it is twice as big as the latest to go into action—at Oldbury, in W. England.

Food Irradiation in Chile

Chile is beginning the development of a comprehensive irradiation programme designed to allow preservation or treatment of various foods important to Chilean agriculture or nutrition. The programme will enhance food conservation and distribution in response to the needs of the country's economy. Various governmental agencies, including those in charge of atomic energy, agriculture, fisheries, national health and national development, as well as the University of Chile, are involved. Research grants or technical assistance are coming from the IAEA, the U.N. Special Fund, and the Pan American Health Organization. A 100-curie cesium-137 irradiation source, an 0.8-MeV accelerator, a 22-inch cyclotron, and a 1-MW swimming pool reactor will be used. Besides this, the Chilean Government will have use of a gamma source in Lima, Peru, for joint investigation of fruit fly irradiation, and possibly will cooperate in marine product irradiation with Argentina.

Sprout inhibition in potatoes, insect disinfestation in corn, wheat, and other grains, and fish and seafood preservation will be investigated. Chile is especially interested in potato irradiation, because potatoes are a staple of the country's diet. Seafood, because of its high protein content, should be consumed in greater quantities than it is; the Government believes irradiation may allow better distribution of sea products throughout the country, raising the nutritional level of its citizens.

Economic feasibility of the various uses of irradiation will be carried out simultaneously with the scientific investigation. In addition to food applications, irradiation of blood and medical supplies is also being investigated.

Forest Irradiation in Canada

A long-range study of the effects of low-level radiation on an environment, the first of its kind in Canada, is being undertaken by Atomic Energy of Canada Ltd. The study is being directed by botanist Dr. Janet R. Dugle and undertaken by the environmental control group at Whiteshell Nuclear Research Establishment in Manitoba. The irradiation area will be a one-quarter-mile square forested area near Whiteshell; it has been isolated by a firebreak and will be fenced in. The first three years of the study will consist of surveying and taking a census of the plants and animals in the area. Then the area will be irradiated for one year with a 10,000-curie cesium-137 irradiator, following which the effects on the plants and animals will be evaluated.

Besides being the first experiment of its kind in Canada, it is the first such study of this type of forest, although a similar study has been made in a Puerto Rican rain forest.

(*Nuclear News, October* 1969)

Electronics at Trombay

(*Continued from page 5*)

work on the consolidation and expansion of the production facilities at the Bhabha Atomic Research Centre should be taken up expeditiously. In the meantime these and other deliberations had given rise to the creation of the National Committee on Electronics chaired by the late Dr. H. J. Bhabha. This committee which went into the problem of the consolidated needs of the country in the field of electronics, estimated that, within the next ten years' period, the electronics industry in India would have to develop exceedingly fast, if it were to satisfy the requirements of a fast expanding economy. The national requirements were such that by the year 1975, electronics production at a level of about Rs. 300 crores per year was envisaged. The emergency a few years ago has only served to highlight the need for freeing the country from the shackles of foreign know-how in the entire gamut of the electronics industry, right from the production of basic components and hardware to the ultimate design and development of the most sophisticated instruments and systems.

These considerations led to the establishment in 1967 at Hyderabad of the Electronics Corporation of India Limited to undertake commercial scale production of instruments and systems developed at the Bhabha Centre.

While the Corporation functions as a separate commercial organization, a considerable amount of research and development effort continues to be concentrated in the Bhabha Atomic Research Centre.

Self-Sufficiency

Today, the electronics programme of the Atomic Energy Commission, which started off as a minor effort towards achieving limited objectives nearly 15 years ago, has been transformed into a gigantic undertaking which will go a long way towards making India self-sufficient in the field of electronics. Work on the latest developments in electronics, such as nanosecond techniques, micro-miniaturization and space electronics is also well under way. The Centre's efforts during the past 15 years have demonstrated unequivocally that Indian scientists and engineers, given the right opportunity and environment can not only bring India up-to-date but also advance the frontiers of knowledge in this sophisticated field. ●

Science Journal Is Century Old

N*ATURE* the internationally famous British science journal, has just celebrated its centenary.

Published in London by Macmillan, this weekly journal, which appeared for the first time on November 4, 1869, holds a prominent place as a channel of communication among research workers and between scientists and the outside world.

More than two-thirds of its circulation is outside Britain and letters to *Nature* have been the accepted method of reporting results of research throughout the journal's history.

Mechanical flight, radioactivity, the cathode-ray tube for picture transmission, the discovery of the neutron, the synthesis of penicillin and the unravelling of the genetic code—all these and many more scientific discoveries and revolutionary developments were first reported in *Nature*.

The journal was originally the idea of a civil servant, Sir Norman Lockyer, who felt that scientists were handicapped because they had no common vehicle of communication. He was supported by many famous 19th century scientists (*Roy Herbert, BIS*).

“ Crop Plants Must Be Bred to Make Efficien

(Continued from page 4)

Fertilizers must be bought by the farmer and in the developing countries may represent the only cash outlay of the farmer in addition to a hard currency import for the country. It is therefore imperative that fertilizer is not wasted. It must be applied at the correct time, placed correctly in the soil and be in the most usable chemical form to ensure the most efficient uptake by plant roots. By using isotopic forms of the elements concerned, it becomes possible to make use of two qualities. One is the ability to detect them in minute quantities and the other the ability to distinguish the added fertilizer nutrient from that present in the soil. Thus a unique method is available of studying the fate of applied fertilizers in the soil and their movement from the soil into the plant. Isotopes provide the only direct method of measuring the uptake from the fertilizer.

Fertilizer Management

An example of this application is the determination of the most efficient place to put a fertilizer to ensure maximum uptake by the plant. By labelling a phosphorus fertilizer with the radioactive isotope (phosphorus-32) a quantitative determination can be made from which place in the soil the plant is best able to take up this added nutrient element. This is only possible because the radioactive phosphorus can be distinguished from the phosphorus native to the soil.

Applying this technique to studies of efficient placement, timing and chemical composition of fertilizers, the Joint Division has organized several internationally co-ordinated programmes in rice, maize, wheat and tree crops. The results of these programmes have provided answers to many questions of fertilizer management and have in some cases already been extended to farmers.

In soil moisture studies, nuclear techniques also provide a quick and efficient way of soil moisture determination, based on the principle of neutron scatter measurements. The Joint Division has assisted a number of countries which have limited water resources in this application.

The Division has organized a number of scientific meetings dealing with soil and water studies and has responsibility for various technical assistance projects which will be dealt with later.

How Plants can be Changed

In order to achieve peak production, crop plants must be bred to make efficient use of high levels of fertilizers, plus the ability to withstand diseases and pests. They must also be of high nutritional quality and possess numerous other qualities influenced by preferences of the consumer or the practical requirements of handling commodities.

Plant breeding involves the combination of a set of desirable characteristics in a single crop variety. Its success depends largely on the variability in plant characters available for recombination and selection. All variability in plants as well as in animals and man derives from mutations, which are sudden changes in the genetic make-up, taking place during evolution as a result of cosmic radiation and other factors. Present forms of life represent the result of natural and artificial selection of the limitless mutations which have occurred throughout aeons of evolution and recombination.

New Environment

During natural evolution of plants, only those mutations are selected which contribute to the plant's ability to survive and reproduce. Primitive agriculture supplied the selection pressure which resulted in the so called crop plants, *e.g.* the cereals.

Modern agriculture, using huge amounts of fertilizers, mechanized field management and demanding specific requirements as to the chemical composition of the products, *e.g.* balanced amino acid composition, represents a totally new selection environment. Not many mutations which could have met these requirements and occurring during evolution, have been preserved in present-day plants.

If plant breeding were solely based on existing variability, there would be little hope for sustained progress in plant improvement. Fortunately we now have the tools, primarily in ionizing radiations and some selected radiomimetic chemicals, to increase vastly the rate of natural mutations. The science of applying this tool effectively in plant breeding has taken a long time, but now, thirty years after the discovery of artificial mutagenesis, this technique has become an important means of breeding plants.

Sharbati Sonora

One of the chief advantages of mutation breeding is the ability to improve a single feature in a variety without significantly altering the otherwise desirable make-up of agronomic characters in the variety. For example, a well adapted and accepted local variety lacking in straw strength can be shortened and strengthened in this way, resulting in much higher yields. Many crop varieties have resulted from this kind of breeding, *e.g.* the highest yielding rice variety in Japan, Reimei, three varieties of durum wheat in Italy, barley varieties in Sweden and USA. Examples of early-maturing mutations can be found in a Japanese soybean variety, a Swedish barley and Japanese rice.

Mutation has also been used to improve certain defects of high-yielding introduced varieties. Thus in India one of the high-yielding Mexican varieties of wheat, Sonora 64, a red-kerneled type, was adapted to Indian consumers, who preferred an amber-coloured grain, by radiation treatment. The variety Sharbati Sonora was the result.

Another advantage of mutation breeding is the ability to increase variability thus widening the base of selection. Of great significance is the

Use of Fertilizers, and Withstand Diseases”

relatively short time required to breed a new variety by this technique. Thus the variety Sharbati Sonora was on the market three and a half years after the gamma ray treatment, about half the time required by other methods. Finally in vegetatively propagated crops, mutation breeding represents the most efficient methods, and in asexual crops is the only method available since no hybridization can be carried out.

As a result of recent progress in mutation breeding we now find, as an example, that most of the winter barley grown in the USA results from an induced mutant, as well as most of the navy beans grown there. Induced mutants are now a part of nearly all barley breeding programmes in Northern Europe and mutant varieties are becoming the most widely grown rice in Japan and wheat in India and Italy.

Induced Mutations

The Agency/FAO Division has organized international programmes dealing with research to improve the mutation breeding technique including more efficient use of neutrons for seed irradiation. One programme deals with use of induced mutations in rice breeding, another with testing in over 20 countries of mutant varieties of durum wheat. A programme now being developed deals with the use of radiation and radioisotopes in breeding and selecting for improved protein quality and quantity in crop plants. Other activities include scientific meetings and technical assistance.

Animals

Both radiation and isotopes play an important role in various aspects of animal production and health, although, unlike plants, radiation cannot be used, at least yet, for breeding livestock. One of the important problems connected with livestock production, particularly in subtropical areas, is posed by a variety of parasites which significantly reduce production potentials, and in some instances, nearly prevent the economic raising of livestock.

Parasite control is exceedingly difficult. Vaccines such as are used against bacterial and viral diseases cannot be produced. In fact, the only known method of producing helminthic vaccines is their attenuation by radiation. Radiation-produced vaccines are already available commercially and the Division is promoting internationally co-ordinated studies to extend these applications to further parasite pests.

Another problem in which radioisotopes play an important role is animal nutrition, and in particular, mineral nutrition. Isotopic tracers are used to follow the metabolic pathways of a particular nutrient from the feed through the animal and its deposition in the various tissues and products.

Phosphorus metabolism and deposition in bones, iron metabolism and blood investigations, iodine and the function of the thyroid; the pathways of nitrogen and sulphur in connection with protein synthesis, are among studies which are supported and coordinated. A number of scientific meetings have been organized and technical assistance projects supervised as mentioned later.

Fighting Against Destructive Pests

Food must be protected both during production in the field and in storage. The application of radiation to animal parasites has been referred to before, but there are many other areas where nuclear techniques make important contributions. The biggest cause for food losses are insects and related animals. Insects attack livestock as well as crop plants at all stages of growth. The tsetse fly is not only a dangerous disease carrier in man but prevents vast acreages in Africa from being used for raising of livestock. Another serious animal pest is the screw worm.

Radiation Sterilisation

Of insects attacking crops one can mention the rice stem borer, the Mediterranean fruit fly, the olive fly and the codling moth attacking apples. These pests are all examples of insects species for which the use of nuclear techniques may provide an efficient means of control or eradication. The screw worm has already been essentially eradicated from the United States. Attempts at controlling the other species using nuclear techniques are in various stages of progress.

In order to achieve control, radiation is used to sterilize vast numbers of insects. Actually the insects are technically not sterile but transmit dominant lethals within germ plasm. These insects are released in infested areas where they compete with the natural population during the mating season. Since matings involving sterile insects do not result in offspring, the native population is reduced in the following generation. Subsequent releases of overwhelming numbers of sterile insects can, within a few generations and in a well-conducted programme, completely eradicate the species from the release area as was done with the screw worm. The chief advantages of this method of control are :

1. Only one insect species is affected, *i.e.* other beneficial insects and other wildlife are not affected ;
2. No harmful chemical residues are left since no chemical is applied.
3. It is possible to expect total eradication from a given area.

The chief problems encountered are :

1. The need for and difficulty in mass rearing of enormous populations of the insect ;
2. The high overhead cost of mounting a large programme ;
3. The difficulty of getting funds for pilot trials ;
4. The efficient organization required to carry out a successful programme.

This so-called sterile male technique is the chief entomological concern of the Joint Division. It is involved in demonstration projects with Medfly in Central America and Italy. The

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Division co-ordinates studies on various insects including the use of isotopic tracers to study insect ecology, dispersal, and habits. A number of scientific meetings have been held to discuss radiation entomology.

There are other aspects of food protection which receive the attention of the Joint Division. One is the serious problem presented by residues of harmful chemicals which can be found on food items following treatment with various pesticides. Although potentially a serious threat to human health, these residues and their metabolic products are often present in such minute quantities as to defy detection and investigation by conventional analytical techniques. Neutron activation analysis is unique for their detection and the application of radioactive tracers is indispensable in studies of the fate of pesticide residues. The Joint Division is now preparing to establish international programmes in this field.

Environmental Contamination

Another aspect of food protection is concerned with contamination caused by atomic energy itself. This includes contamination from the products of fallout from nuclear explosions and such contamination which can occur following reactor accidents or as a result of atomic waste materials. The Division, in co-operation with other responsible bodies keeps a watch over such environmental contamination and reports to the UN.

Helping to Preserve Food

The ability of ionizing rediations to penetrate matter and to kill cells and tissues in the process has long fascinated food technologists. For many perishable food products such as certain fruits which can neither be cooked nor treated with other conventional methods of preservation, radiation treatment seems to be the only way of increasing storage life. For other products such as grains, radiation treatment will disinfest without leaving residues: for still other products such as fish and certain meats, it will significantly increase shelf life enough to permit marketing of a nearly fresh product.

Radiation can effectively suppress sprouting in potatoes—or using the technique differently—cause immediate sprouting. Onions, too, can be preserved in this matter and ripening of fruits, such as bananas and pears, can be delayed.

Th problems encountered with radiation preservation are similar to those encountered with any other method of food treatment. The effect on the colour, taste, and quality of the products must be reduced to a minimum and one must be sure that the product is no more adversely affected than by other comparable treatments such as smoking, salting, deep-freezing or cooking.

Until recently, the Division has been chiefly concerned with the technology of food irradiation, the operation of pilot plants, various studies concerned with the effects of radiation on food, and questions concerning legislation for irradiated food products. The emphasis is now being shifted somewhat towards wholesomeness testing of irradiated foods and to establish a clearing house for information relating to petitions for clearance of irradiated food.

Other Activities

The work of the Joint Division is related to the various subjects described. Most of the scientific programmes are carried out in co-ordinated programmes in a number of countries on the basis of research contracts and research agreements. In connection with these programmes, the Division has arranged a number of co-ordinated meetings in various places. The IAEA Laboratory at Seibersdorf, Austria, carries out a large agricultural programme for which the Division has technical responsibility. The laboratory activities form an integral part of the co-ordinated research programmes and render services of various kinds to Member States and provides training in nuclear applications. The Division also technically supervises a number of activities funded by the Agency's regular programme of technical assistance and the United Nations Development Programme. The Joint Division has supervised a number of training courses and has technical responsibility for three Special Fund projects. One of them, in Yugoslavia, resulted in a well-equipped nuclear laboratory and a core of well-trained staff which is now carrying out a vigorous programme of scientific research. A similar but much larger project is being implemented in India. In Central America a demonstration is in progress of the application of the sterile-male technique on the Mediterranean fruit fly.

The basic philosophy is that the best way to ensure sustained economic and social progress in the developing countries is to develop the capability of the countries themselves by thorough training, by supporting local research to solve local problems, but at the same time to foster co-operation and co-ordination among scientists in different developing and developed countries facing similar problems, in order to bring them in contact with the scientific community.

Nuclear tools are of great significance in agricultural research and production, as a valuable addition to those already in use. The Division would strongly advise against their use if inappropriate. It will strongly promote their use where they are likely to solve problems better or quicker than is possible with other means or if, as is sometimes the case, they provide the only means of solving a problem. (*Courtesy: IAEA Bulletin Vol. II, No 4,* 1969. *The article is based on information presented by the authors at a July symposium in Kinshasa, Democratic Republic of the Congo, organized by the Organization of African Unity and supported by the Agency, on the peaceful uses of atomic energy in Africa.)* ●

SATELLITE SENTINELS AND FLIGHT SAFETY

Astronauts travelling to the Moon and beyond and the crews and passengers of high-flying supersonic jets like Concorde, could be in danger of sickness caused by solar radiation. To overcome this a group of scientists in the Space Department at Leicester University are finding out how to predict the solar storms which send out the dangerous radiations. The team led by Dr. Kenneth Pounds is doing this by means of X-ray telescopes mounted on a rocket launched as part of an international effort by the European Space Research Organisation. (ESRO.)

A partial eclipse of the Sun. During total eclipses astronomers can see the corona and sometimes even flares.

A typical solar flare.

ALTHOUGH the launch took place last November it is only now that the Leicester scientists have analysed their results far enough to be able to give their tentative but exciting conclusions. They mounted a spectrometer, an instrument which measures the quantity and wavelengths of various kinds of radiation, in an attitude control unit built by the British electronics firm Elliott Automation. This beautifully engineered unit kept the spectrometer pointed at the Sun's centre throughout most of the rocket's flight with an accuracy of 1/300 of a degree. The rocket was launched from ESRO's range at Salto di Quirra in Sardinia, during a solar storm. A computer processed the information during flight on board the rocket before telemetering it back to Earth. This alone saved months of computing on the ground.

Surprising Result

The space scientists got more than they hoped from this single shot. For instance, they found that it was possible to work out what kind of atoms and which elements were producing the X-rays. This was done by measuring the wavelengths of the rays very precisely. The surprising result is that there seems to be about ten times the quantity of some of the elements in the outer fringe of the Sun, the solar corona, than had been expected. There is ten times more silicone, iron, nickel and magnesium. The atoms of these elements are big and complex, and are built up in the centres of the stars by nuclear fusion. During fusion the atoms of smaller and lighter elements beginning with the simplest of all—hydrogen, (which makes up about 90 per cent of the universe) are joined together to form the more complex atoms of the heavier elements. How such a high proportion of the heavy elements get out of the sun's core and into the corona is an unanswered question. The X-rays are produced by heating the heavy elements to temperatures as high as 10 million degrees Celsius, the temperature of the corona during solar flares. But what intensifies this effect at certain times, to cause hard radiation powerful enough to cancel space flights or possibly ground supersonic aircraft, is still unknown.

Predicting Solar Flares

The space scientists at Leicester are searching for a pattern of changes in every kind of radiation coming from the Sun, and especially what takes place just before so that it could be used as a means of predicting a dangerous solar flare well in advance. Relatively harmless X-rays are the advance guard of a solar flare. They take about 8 minutes to get to the Earth from the Sun, but within about an hour, if the flare is a dangerous one, they could be followed by a lethal proton radiation.

Because solar storms interrupt long distance radio communications, knowing when they are coming would be enormously valuable in that field too. Eventually scientists hope to have sentinel satellites keeping watch for changes in the pattern of radiation from the Sun that would give warning of a coming storm. (*Courtesy: SPECTRUM, No.62/69*)

Trombay Seminar

(Continued from page 2)

and others occupying vast areas is quite low. Even in wheat and rice the quality in high yielding varieties needs attention. In these and other crops where conventional methods have not brought about quick results, radiations and chemicals should hold promise. In order that the new tools are effective, review of the progress and recognition of the peculiar problems in each crop are prerequisites before one embarks on mutation breeding."

Earlier Dr. A. R. Gopal-Ayengar, Director of the Bio-Medical Group of BARC emphasized that mutation breeding required persistent and patient efforts over a period of years. He stressed the need for ongoing programmes of fundamental studies for successful launching upon applied aspects of research programmes.

Dr. M. S. Swaminathan, Chairman of the Food and Agriculture Committee of the Department, and Director of the Indian Agricultural Research Institute, New Delhi, also addressed the participants. ●

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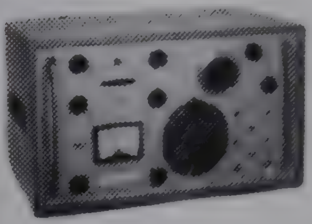

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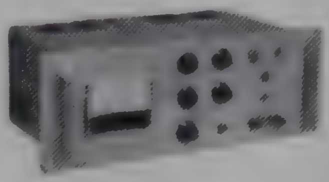

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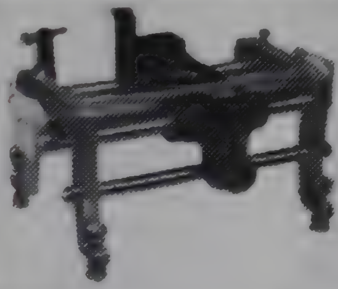

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Tarapur Ushers Era of Nuclear Power in India

TARAPUR ATOMIC POWER STATION
DEDICATED TO
THE PRIME MINISTER
SHRIMATI INDIRA GANDHI
JANUARY 19 1970

The Prime Minister unveils a plaque at Tarapur to mark the dedication of the Station.

ON January 19, the Prime Minister Smt. Indira Gandhi formally dedicated the 400 MWe Tarapur Atomic Power Station to the people of India.

Located on the west coast, about 100 km. north of Bombay, Tarapur is India's first nuclear power plant and the largest atomic station in Asia today. The Station became operational in October last year and, till the day of dedication, had generated over 880 million units of power to the two States of Gujarat and Maharashtra which share its output.

Addressing the guests, the Prime Minister said the occasion marked a new phase in India's history. With the Station's commissioning she said, India had joined the select band of nations which uses atomic power for the advancement of human welfare.

Kindred Soul

Tarapur she said, represented the partial realization of a dream shared by two people — her father, Jawaharlal Nehru, and Homi Bhabha. Jawaharlal Nehru was convinced that only science and rational thinking would help the people to overcome their old and deep-rooted poverty and win the respect of other nations. And in Dr. Bhabha, she added, her father found a kindred soul.

The Tarapur project, Smt. Gandhi continued, is a symbol of international cooperation. It would not have come into being but for the world-wide urge to work together on the peaceful uses of atomic energy, promoted by the Geneva Conferences under U.N. auspices. The project she said, marked the beginning of the second stage of India's technological revolution. To those who made wry remarks about a cow-dung economy wishing to go in for nuclear energy she said, Dr. Bhabha had convincingly explained the technological fallout which results from atomic energy and the impact

(Continued on page 2)

"Tarapur

Shri M. N. Chakravarti, Tarapur Project Administrator and Dr. Vikram Sarabhai, Chairman, Atomic Energy Commission conduct the Prime Minister around the Station.

(Continued from page 1)

it has on other fields of economic and scientific activity.

The cooperation between the United States and India in the Tarapur Project, the Prime Minister stressed, had helped Indians to gain valuable competence which would enable them to build the Kalpakkam station on their own.

In the last twenty years she said, India had been engaged in building up its infrastructure. The developing countries were in the advantageous position of stepping over several intermediate and not-so-essential stages. If the building of the infrastructure itself incorporated higher technology, future progress would be further accelerated. It was this point of view she said that gave significance to the work of the Atomic Energy Department.

Welcoming the guests, Dr. Vikram Sarabhai, Chairman of the Atomic Energy Commission said that the smooth progress of the project was in no small measure due to the efficiency and dedicated work put in by members of the Tarapur Board created by Dr. Bhabha. The Board, he said, had provided a link with the Bhabha Atomic Research Centre which had borne the brunt of the task of providing not only men with special skills, but technical advice and specialized services as required. The pattern of organization that was evolved for Tarapur in its project phase, Dr. Sarabhai stated, would serve as a model for later atomic power projects and other industrial projects for nuclear fuel and heavy water.

Referring to the costs of nuclear projects, the Chairman said it was understandable that in India, with its scarce resources, every investment should be examined in terms of the returns it would bring. While it was good discipline to have an eye on capital costs of the first nuclear power stations and the price at which electricity could be sold, he maintained that in examining the direct financial aspects, particularly for a project such as the Madras Atomic Power Station, which was being built by the country for the first time on its own, it should be noted that India was not merely building power stations but also creating a new national capability of great economic significance in the long run.

Citation to Tarapur

Mr. James T. Ramey, Commissioner, U.S. Atomic Energy Commission, said the occasion was of profound significance not only for India but also for those many other developing nations for whom India was a natural and inspiring leader. By showing that nuclear power is attainable for those willing to take the long, careful and difficult preparatory steps, India had benefited itself directly and its friends by example, he said.

To commemorate the successful completion of the project, Commissioner Ramey presented a citation to the Tarapur Project authorities on behalf of the U.S. Atomic Energy Commission.

en Us Valuable Competence"

Mr. James T. Ramey, Commissioner, USAEC presenting a citation for the Tarapur Project authorities to Dr. Vikram Sarabhai.

Giving the vote of thanks, Shri M. N. Chakravarti, the administrator of the project, looked back over its beginnings. "One would find it difficult to imagine," he said, "that this place where we stand, as a symbol of India's entry into the atomic power age was not so long ago, a waterlogged bush-covered area." "The wind of change seemed to have bypassed Tarapur and we had to use that most hardy animal of transport — the bullock." The transformation of Tarapur from the bullock-cart age to the age of atomic power within the short span of a few years, he said, gave the measure of both the extent and speed of the progress that had been made.

Shri V. P. Naik, Chief Minister of Maharashtra, and Shri Babubhai Patel, Minister for Public Works and Electricity, Gujarat, also spoke on the occasion. Among the distinguished guests were Dr. Sigvard Eklund, Director-General of the International Atomic Energy Agency, Mr. M. Piccagli from the World Bank, the representatives of the Atomic Energy Commissions of countries with which India has close ties, particularly, Mr. M. C. Timbs from Australia, Dr. L. R. Haywood from Canada, Dr. B. Goldschmidt from France, Dr. Budi Sudarsono from Indonesia, Prof. C. Salvetti from Italy, Dr. H. Brynielsson from Sweden, Sir Charles Cunningham from the U. K., Commissioner James T. Ramey from the U.S., Dr. H. Kramer from W. Germany, and Dr. Vogin Gazina from Yugoslavia. ●

Messages

Over 50 congratulatory messages were received by the Atomic Energy Commission for the Dedication from members of Atomic Energy Commissions and from Ministers, individual scientists, businessmen and government officials in India and abroad.

The President of India, Shri V. V. Giri wrote :

The Tarapur Atomic Power Station symbolises our resolve to utilize nuclear energy for peaceful purposes and for raising the standard of living of our people. I send my heartiest congratulations to all concerned with the successful completion of this sophisticated project and hope this will be a precursor of many more such bold and imaginative ventures.

The Vice President of India, Shri G. S. Pathak said :

The establishment of this Power Station has been a very significant step in our efforts for utilizing nuclear energy for peaceful purposes. I congratulate the scientists, engineers and administrators who have been associated with our nuclear energy programme.

Shri K. L. Rao, Minister for Irrigation and Power, Government of India, wrote :

The dedication of the Tarapur Atomic Power Station by the Prime Minister marks an important and significant stage in the development of the country. The Project which outside Japan is Asia's first, places India on the nuclear map of the world. It is an eloquent manifestation of the peaceful uses of atomic energy to which our nation is committed. Power from Tarapur to the extent of as much as 400 MW corresponding to 2800 million

(Continued on page 14)

“Partial Realization of a Dream of Two People

Excerpts from the Prime Minister's speech at the Tarapur Dedication Ceremony

THIS moment marks a new phase in our technical history. With the commissioning of the Tarapur Power Station, we join the select band of nations which uses atomic power for the advancement of human welfare.

Tarapur represents the partial realisation of a dream shared by two people — my father and Dr. Homi Bhabha. Jawaharlal Nehru was convinced that only science and rational thinking would help us to overcome our old and deep-rooted poverty and win the respect of other nations. In Dr. Bhabha he found a kindred soul.

You all know that the Tarapur Power Station has been in operation for the greater part of a year and has already proved its usefulness. It has enabled Maharashtra to overcome its shortage of power to a large extent and to make fuller use of its industrial force. Gujarat has similarly benefited. In the coming years, Tarapur will increasingly contribute to our national wealth.

Technological Fallout

The project is also a symbol of international cooperation. It would not have come into being but for the world-wide urge, which was promoted by the Geneva Conferences under U. N. auspices, to work together on the peaceful uses of atomic energy. Tarapur marks the beginning of the second stage of our technological revolution. To those who made wry remarks about a cow-dung economy wishing to go in for nuclear energy, Dr. Bhabha convincingly explained the “technological fall-out” which results from atomic energy, and the impact it has on other fields of economic and scientific activity. In the last 20 years, we have been engaged in building our infrastructure. The developing countries are in the advantageous position of stepping over several intermediate and not-so-essential stages. If the building of the infrastructure itself incorporates higher technology, future progress will be further accelerated. It is this point of view which gives significance to the work of the Atomic Energy Department.

The AEC has already been working for the application of atomic energy to agriculture, food preservation, medicine and industry. It has also taken up studies of the benefits that will accrue to agricultural regions through the establishment of low-cost energy centres.

India-U. S. Partnership

Tarapur is the result of cooperation between the United States and India. It is a turn-key project, planned by U.S. scientists and built by U.S. technicians, but our own scientists and engineers were closely associated with all the stages of its construction. From Dr. Bhabha and Dr. Seaborg down to the youngest scientist, there has been a sense of partnership. Indians have thus gained valuable competence which will enable us to build the Kalpakkam atomic station on our own.

We feel that a country as large as ours with its rich and variegated technical talent should work progressively towards self-reliance. Our past experience has been that aid can be stopped at crucial moments. Also the cost of repaying and servicing old loans is assuming proportions which cut severely into the net aid available. However, the development of indigenous know-how does not mean the end of international cooperation. We welcome such collaboration on a basis of mutuality, for we should like to profit from developments in other countries. In turn, we are eager to make whatever contribution we can to the world-wide development of peaceful uses of atomic energy. We think our experience should be particularly useful to other developing countries.

Role of Science

Tejo-si, tejo mayi dhehi (thou art Energy, give me Energy) was the prayer of our ancients. The growth of Man's mind has been marked by the ability to discover and utilise newer sources of energy. What a long way we have come from the days when Man first lit a fire to the present times when we tap the vast store of energy packed in atoms.

Science is neutral, and its discoveries can be used for good or evil. How sad, that it has so often provided the tools for war. Naturally, it was the two world wars which gave contemporary scientific advance its thrust. The scientist himself does not always have much say in the uses of science and sometimes even worthwhile uses have harmful side effects, the upsetting of natural balances, the extinction of species, the pollution of air and water. Atomic energy itself represents the most fearsome aspect of destruction. Yet the role of science, especially that of atomic energy, makes itself equally felt as creator

Scientific Progre

Excerpts from Dr. Vikram Sarabhai's speech at the Tarapur Dedication Ceremony

EARLY in March 1958 two remarkable resolutions were made by the Government of India. The Scientific Policy Resolution announced, and I quote: “The key to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors: technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. But technology can only grow out of the study of science and its applications.

Inherent Obligation

“Science has not only radically altered man's material environment, but, what is of still deeper significance, it has provided new tools of thought and has extended man's mental horizon. It has thus influenced even the basic values of life, and given the civilisation a new vitality and a new dynamism.

It is an inherent obligation of a

ed Trombay, he remarked on the coincidence that just opposite, across the waters of the Bombay harbour, was the famous old sculpture representing Mahesha in one form as creator, preserver and destroyer.

Only for Preservation

India's long tradition of humanism has endeavoured to synthesise human values. It is all the more necessary to remember these values when we handle forces which are so full of destructive potential as atomic energy. We have declared that we shall use atomic energy only for preservation and not for destruction. We must all work to make the kind of future we desire.

Jung quotes Heisenberg as saying: "The space in which man has developed as an intellectual being, has more dimensions than that of the

(*Continued on page* 11)

Inspiring Example to Developing Nations

(Excerpts from the speech of Commissioner James T. Ramey, at Tarapur)

THIS occasion is of profound significance not only for India but also for those many other developing nations for whom India is a natural and inspiring leader. By showing that nuclear power is attainable for those willing to take the long, careful, and difficult preparatory steps, India has benefited itself directly, and its friends by example.

In adopting nuclear power, India, has trained new cadres of people not only in the advanced scientific and engineering disciplines required in the field of nuclear power, but also at the level of skilled craftsmen and plant operators. In developing these new skills, the atomic energy programme has not only filled its own requirements, but has made a major contribution to upgrading India's industrial capability in many areas of modern technology.

Exciting Future

The Tarapur Station is now capable of supplying about 400,000 kilowatts of electric power to the largest electrical grid in India. There is much to be gained from meeting the technical challenge of establishing high standards for operation and maintenance of the plant. For it is only the first of many nuclear plants which will meet, from largely indigenous resources, a major share of India's rapidly increasing electrical generating requirements.

Through its ability to generate very large blocks of truly low-cost power regardless of location, nuclear energy has the capability of helping to free developing economies which are nearing maturity from the classic shortcoming of high-cost fossil power. By building large nuclear power facilities and electrical consuming industries at the same time and in close proximity, in what we term "energy centres," it may be possible to achieve the benefits of low-cost power in developing countries sooner than would otherwise be possible. In arid areas, large quantities of desalted water would be a principal product of these energy centres.

Dr. Sarabhai has reported to the IAEA on a possibility of especially great interest where energy centres might supply the pumping power necessary for the irrigation of vast areas of the Gangetic Plain, taking advantage of extensive underground water resources underlying this area of India. In combination with modern, high-productivity agricultural practices, this approach could open new horizons in meeting India's food requirements. The Mithapur area in Gujarat also offers possibilities, including a role for desalted water. In studying these possibilities, as well as other important aspects of the future role of nuclear power in India's development, cooperative arrangements

(*Continued on page* 14)

Tribute to Nehru and Bhabha

great country like India, with its traditions of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today".

The resolution was preceded four days earlier by another relating to the constitution of the Atomic Energy Commission which stated: "... India should be able to produce all the basic materials required for the utilisation of atomic energy and build a series of atomic power stations, which will contribute increasingly to the production of electric power in the country. These developments call for an organisation with full authority to plan and implement the various measures on sound technical and economic principles and free from all non-essential restrictions or needlessly inelastic rules. The special requirements of atomic energy, the newness of the field, the strategic nature of its activities and its international and political significance have to be borne in mind in devising such an organisation."

The unmistakable hand of Shri Jawaharlal Nehru and of Homi Bhabha can be clearly seen behind these resolutions.

For the management of Tarapur as a Project, Bhabha created a special Board which was presided over by the Project Administrator and had as its members three leading scientist/engineers from the Bhabha Atomic Research Centre as well as an administrator from the Department of Atomic Energy. This Board has shouldered heavy responsibilities for Government decisions related to the project and the smooth progress of the project is in no small measure due to the efficiency and dedicated work put in by the members of the Tarapur Board. The Board has also provided a link with the Bhabha Atomic Research Centre which has borne the brunt of providing not only men with special skills but technical advice and specialised services as required. Moreover, extensive back-up of a programme for safety in the Tarapur environment has also been undertaken through this link with our Bhabha Atomic Research Centre. In future, the operation and maintenance of this Station would be the respon-

(*Continued on next page*)

Need for National Polic

(Continued from page 5)

sibility of an Atomic Power Authority which is to be newly created under the Atomic Energy Commission. But the pattern of organisation that was evolved for Tarapur in its project phase has served as a model for later atomic power projects and the other industrial projects for nuclear fuel and heavy water.

In our country with scarce resources, it is understandable if every investment is examined in terms of the returns it can bring. It is moreover a good discipline for all of us to have an eye on the capital costs of our first nuclear power stations and the price at which electricity can be sold. But in examining the direct financial aspects, particularly for a project such as the Madras Atomic Power Station which we are for the first time undertaking entirely on our own, let us note that we are not merely building power stations but also creating new national capability of great economic significance in the long run.

"Electrification," Lenin had said, "will make it possible to place the country's economy, including agriculture, on a new technical basis, on the technical basis of modern large-scale production. Only electricity can constitute such a basis." There is a remarkable correlation between per capita gross national product and the per capita energy consumption for the nations of the world. Developing nations and particularly India are at the bottom of the ladder and the industrially advanced countries at the top. Correlations do not necessarily signify a direct cause and effect relationship but let us make no mistake about the fundamental necessity of energy to increase human productivity in agriculture, as in industry.

India has been fortunate in achieving during the first three Plan periods a doubling time of five years for its installed generating capacity. This corresponds to a compound growth rate of 15 per cent per annum. Any growth rate of installed power on a smaller scale, in the context of the inevitable growth of population during the next 20 years in spite of the most energetic measures which we might take for population control, is bound to constitute a serious impediment to national development and the eradication of poverty. There would be need in India for fresh installed generating capacity of at least 20,000 MW during the second half of the 70's and of 40,000 MW from 1980 to 1985, totalling 60,000 MW for the decade commencing 1975. Conservative estimates involve a capital investment of Rs. 12,000 crores in electric power plants alone. It is well-known that the economic penalty involved in pessimistic planning of electrical capacity is many times greater than the penalty arising from optimistic planning. In any case, realising that 3 to 7 years are involved in the building of power stations, it is not hard to see why firm planning only on a five year basis for our energy needs repeatedly leads us into serious trouble. If for instance, the industrial establishments which would be called upon to supply annually about Rs. 800 crores of equipment during the decade commencing 1975 do not prepare themselves during the next three or four years with the design capability and the trained personnel on the shop-floor we would either have no development or go out with a begging bowl for external assistance of a magnitude which is in any case unlikely to be forthcoming. Moreover, the types of equipment required in the late 70's in terms of technology and size should be chosen for development *now* if we are not to fall flat on our faces in the task that we have undertaken. What applies to power in general applies equally to nuclear power which should expand at the rate of three times every five years if by 1985 it is to reach a figure of about 8500 MW, constituting about 12 to 13 per cent of the total generating capacity in the country. Business in supplying components for the nuclear power plants should be about Rs. 100 crores annually during the latter half of the new decade.

A good example of the role that nuclear power can play can be seen from our most recent study on the feasibility of an agro-industrial complex in three districts of western Uttar Pradesh, having collectively a population of about 24 million. We can derive a return of 81 per cent on the incremental investment of approximately Rs. 1000 crores with 400 MW nuclear power energising 24,000 additional tubewells and producing elemental phosphorus for fertiliser using an electro-thermic process. Almost half the investment is on what might be termed the infrastructure, involving capital expenditure on augmenting roads and railway transportation, new warehouses, agricultural implements and for providing credit to farmers. The programme would generate all the year round direct employment on farms for 1.4 million persons, resulting in additional agricultural production of 22 million tons and an increase in the gross national product by about Rs. 1,000 crores annually. The profit to the agriculturist is likely to be about Rs. 4,500 per hectare after paying full wages for all labour employed. These figures, dramatic and almost incredible can be understood if we recognise that what we have in fact done here is to use nuclear power as a catalyst, through the water that it pumps up, and the fertiliser that it produces, for harnessing through photo synthesis the vast solar energy falling on the plains of India. The example provides a striking demonstration of the impact that the supply of energy can produce in our countryside where the largest number of under-privileged persons of India reside. To realise the potentialities for the accelerated development of our country we need to clearly understand the role of energy and of water and adopt appropriate policies with determination and commitment. Time does not permit me to elaborate these matters in de-

or Energy

as illustrations.

First we need to exploit underground water resources cooperatively or through local or State Government organisations rather than by individual farmers if we are to optimize the use of these resources with minimum capital and operating costs and spread their benefits equitably to all farmers. There could be a saving of up to 70 per cent in capital costs for the wells and the power supply system if such a policy is adopted.

Second, in order to take advantage of the economies resulting from generating power in large units and using advanced technologies, particularly nuclear power, there should be a reallocation of responsibility as between the Centre and the State Governments to provide for the establishment of new ones and the operation of all large generating stations exclusively by the Centre. It seems that the optimum solution will involve the establishment by the States of "Seed" units of small capacities upto perhaps 10 MWe which could be moved from one place to another after the local load has developed and can be connected to a major grid. Third, the States should have responsibility for the network of secondary transmission lines for rural electrification. However, the Centre should take responsibility for interconnecting principal grids for transmitting bulk power from one area to another.

Further, recognising that nuclear power is today essential for economically supplying energy in large parts of the country, and is moreover the only major supply on which we will need to fall back in perhaps less than 50 years time, we need to commit ourselves to an appropriate programme of atomic power stations. We cannot hope to gain all the great economic advantages of nuclear power unless we develop a mix of thermal and advanced fast breeder reactors.

Seminar on Nuclear Power

(Continued from page 16)

concern to power system planners. Motivated by the power planning requirements during the 4th and 5th Five Year Plans of the Northern Regional Grid interconnecting the states of Punjab, Rajasthan, Uttar Pradesh, Haryana, Jammu and Kashmir, Himachal Pradesh and Delhi they developed a general optimization model for the mix of plants with the objective of determining the mix of thermal, hydel and nuclear plants which gives a minimum unit cost of electrical energy at the load end.

Speaking on the "Indian Experience in Construction of Nuclear Power Reactors," Shri V. Surya Rao, of the Rajasthan Atomic Power Project said that with the transfer of know-how of design and engineering from Canada, self-sufficiency was being achieved by gathering experience and first hand knowledge in construction — a sole responsibility of the Department of Atomic Energy. He said that this had brought in its wake abundant problems relating to procurement of equipment, utilization of available materials, and adopting modern techniques for maximising the utility of these materials both in manufacture and during construction with guaranteed assurance leading to safety. At the Rajasthan Atomic Power Project, he said, most of the problems, including a large scale indigenization programme had been overcome satisfactorily.

Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre drew attention to the fact that developing countries, which for economic reasons wished to develop nuclear power and use nuclear energy for peaceful purposes, were faced with the problem of the creation of a cadre of scientific and technical personnel who could provide the necessary guidance. He held that the problem could be handled by setting up a national complex for research and development.

Messrs V. N. Meckoni and B. P. Rastogi of the Bhabha Atomic Research Centre discussed the various fuel cycle aspects of heavy water reactors such as natural uranium cycle, plutonium recycle and utilisation of thorium. They said that heavy water reactors would play an important role in making a significant contribution to the country's total energy requirements.

Mr. P. W. Mummery, Director of the Atomic Energy Research Establishment, Dounery, England, said that the justification of national nuclear power development programmes and the investments required to initiate and sustain substantial nuclear power installation programmes on a national scale required consideration of alternative strategies. These, he said, must take into account the technical and economic characteristics of different reactor types and different fuelling concepts and the plants, and new investment required, together with consideration of alternative methods of power generation. Consideration, he suggested, must also be given to advanced reactors as well as to the current commercially available nuclear power stations.

Dr. Sigvard Eklund, Director-General of the IAEA outlined the tasks of the IAEA during 1970.

Dr. C. Salvetti, Vice Chairman, CNEN, Italy, spoke on the Nuclear Programme in his country. Dr. H. Brynielsson, Board Member and Adviser, AB Atomenergi, Sweden, outlined the Swedish Nuclear Power Programme while Dr. G. Vendryes, Chief of the Fast Reactor Group, France spoke on Fast Breeder Reactors. Mr. L. R. Haywood, Vice President of AECL, Canada reviewed developments in Heavy Water Reactors in his country. ●

It is my firm belief that the problems of poverty and regional imbalances in our country cannot be effectively tackled without a rational national policy for energy. The dream of Jawaharlal Nehru and Bhabha that atomic energy will be fully competitive with other forms of energy even in the first station that we build is today being realised at Tarapur. ●

Location	:	West coast, 97 km north of Bombay. Project occupies a 526-hectare site, including a 200-hectare township, rail siding and air field.
Capacity	:	400 megawatts. The station consists of two boiling water type reactors, charged with slightly enriched uranium oxide. Heat released by the fission of uranium boils water in the reactor core. High velocity steam is generated which rotates the turbines.
Area to Benefit	:	States of Maharashtra and Gujarat.
August 1958	:	Decision taken to include an atomic power plant in Third 5-year plan.
Mid-1960	:	Tarapur selected from among 20 alternative locations.
August 1961	:	Competitive quotations received from seven bidders from the U.K., Canada, France and the United States.
August 1963	:	India and the United States sign 30-year agreement in Washington for cooperation in development of atomic energy for peaceful purposes. The United States undertook to supply all the requirements of fuel over the period of the agreement and at a cost applicable to domestic users in the U.S. Another provision in the agreement covers the exchange of information on the design, construction and operation of the station, including research and development, and problems of health and safety. Under this clause, during the 30-year period, information will continue to be exchanged on new developments in the technology of power reactors and the recycle of plutonium as a fuel in power reactors.
August 1963	:	Fuel sales agreement with the US AEC negotiated and agreed to in principle, ensuring supply of enriched uranium for the initial fuel charge estimated to cost $ 14.5 mil. (approx. Rs. 10.88 crores) on a long-term deferred payment basis. The contract was signed in May 1966.
December 7, 1963	:	Governments of India and USA conclude $ 80 million (approx. Rs. 60 crores) loan agreement.
May 1964	:	Main contract with IGE executed.
October 1964	:	Start of construction at site.
February 1, 1969	:	Reactor No. 1 becomes critical.
February 27, 1969	:	Reactor No. 2 becomes critical.
April 1, 1969	:	Power generation begins.
October 2, 1969	:	Station on stream.
January 19, 1970	:	Tarapur dedicated to the Nation by the Prime Minister. By January 18, 884.93 million units of power had been generated.

(Reproduced fron

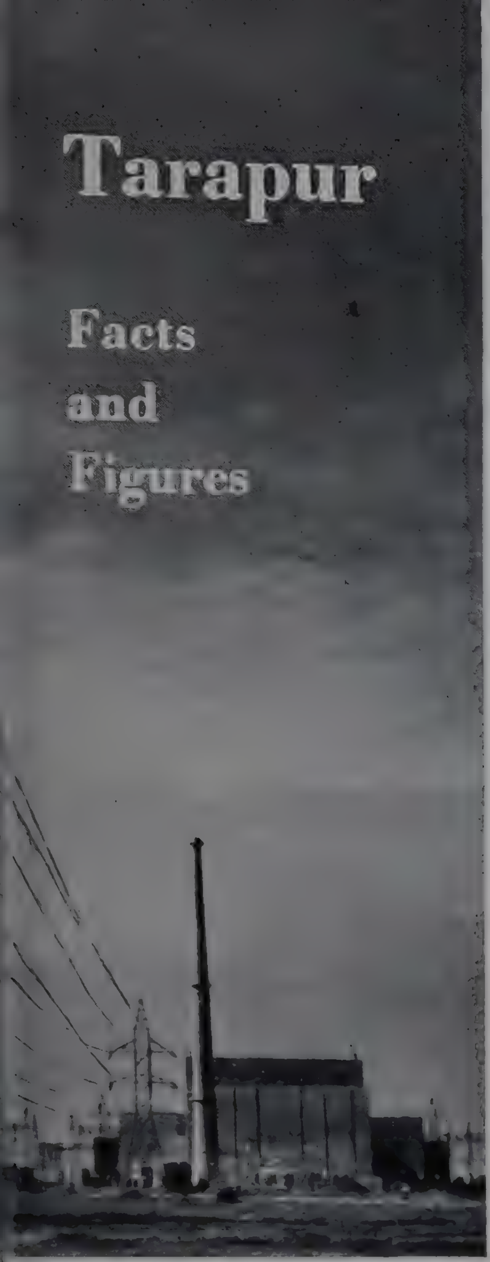
THE completion of Tarapur rep
sents a milestone in India's ato
energy programme.

In August 1958, a decision
taken to include an atomic po
station in the western region of In
in the Third Five Year Plan. In
summer of 1960, Tarapur was sele
ed out of twenty likely sites in
Bombay-Baroda region. Being hig
industrialized, this region's dema
for power runs far ahead of the ava
able load. Lack of fossil fuel a
hydro resources however severely
stricts growth of conventional pov
capabilities. Hydro power potent
in the region is low and fluctuat
as the rivers, being mostly rain-f
are not dependable.

Under the circumstances, nucl
energy was considered the best alt

Tarapur

Facts and Figures



India, July 1969)*

tive. A nuclear power plant is a ady source of power unaffected by lure of rains. Besides, such a plant n operate at a high load factor in : region.

Tarapur is considered by experts to one of the best sites for a nuclear wer station. Being on the coast, plant can draw cooling water, arly 2,200 million litres per day, ht off the sea. Besides, the site s a strong rock foundation, good teorological and environmental con- ions and, in the context of safety, low population density.

The prime contractor for the sta- n was the International General ectric Company of the United ates which was one of the seven lders from the United Kingdom,

(Continued on next page)

Technical Details

GROSS STATION OUTPUT	(KWe)	400,000	(Two units)
NET OUTPUT	(KWe)	380,000	
NET STATION HEAT RATE	(Btu/kwh)	11,860	
REACTOR VESSEL (identical both units)			
Length (inside)	(ft. in.)	53-10	
Diameter (inside)	(ft.)	12	
Weight (with head on)	(tons)	268	
Weight (fully loaded)	(tons)	748	
REACTOR CORE (identical both units)			
Thermal Output	(MWt)	660.9	
Fuel Assemblies		284	
Control Rods		69	
Incore Monitors		13	
Active Fuel length	(in.)	144	
Core Diameter	(circumscribed in.)	103	
Fuel Material	(pellets)	UO_2 slightly enriched	
Cladding		Zircaloy-2	
Initial Fuel Charge	(lbs. U)	87,000	
Average Exposure at Discharge	(MWD/STU)	15,000	
BOILER SYSTEM			
Steam Flow (lb./hr.)	Primary	1,900,000	
	Secondary	790,000	
Cycle		Dual	
External Circulation Loops		2	
Steam Generators		2	
TURBINE			
Type		Tandem compound impulse type with a dual admission single flow high pressure unit and a single admission dual flow low pressure unit.	
Name plate rating	(KW)	210,000	
Exhaust pressure (in Hg absolute)		2.5	
Make up	(%)	0.5	
Speed	(rev/min)	1500	
Primary Steam inlet pressure (dry and saturated)	(psig)	960	
Secondary Steam inlet pressure	(psig)	460	
GENERATOR			
Rating at 0.85 p.f. 0.64 SCR and 30 psig Hydrogen Pressure	(kVA)	248,500	
Voltage	(kV)	12	
Speed	(rev/min)	1500	

Construction Details

Quality Concrete	(cubic yards)	110,000
Reinforcement Steel	(tons)	12,000
Cement	(tons)	44,000
Aggregates	(cubic yards)	105,000
Sand	(cubic yards)	52,000
Piping	(miles)	40
Cables	(miles)	250
Valves		3,800

Tarapur Has Imparted Skill, Confidence

(*Continued from page* 9)

December 7, 1963. Signing of Loan Agreement at New Delhi between the Governments of India and the United States Picture shows Shri L K. Jha, then Secretary, Department of Economic Affairs, Government of India, then U. S. Ambassador Chester Bowles, Prime Minister Nehru and Dr. Bhabha. Under this agreement, the United States gave a loan of 80 million dollars for Tarapur

France, Canada and the United States who responded to the global tenders invited by the Department of Atomic Energy. In December 1963, the United States Agency for International Development granted an aid of $ 80 million (approx. Rs. 60 crores) for the foreign exchange portion of the project. Out of this, a saving of $ 5 million (Rs. 3.75 crores) was made in the course of the project as some equipment and services were procured indigenously.

An Indo-U.S. Bilateral Agreement for Cooperation relating specifically to the Project was signed in August 1963. This agreement includes commitment for fuel supply through the life of the station and exchange of unclassified information relating to research and development including BWR technology and the use of plutonium.

The U.S. Atomic Energy Commission, under a contract signed in May 1966, provided enriched uranium oxide fuel worth $ 14.5 million (approx. Rs. 10.88 crores) for the initial charge, on a long term credit basis. Under the contract, the USAEC will continue to provide fuel throughout the life of the Station.

25-Year Life

Work started on the project in Octber 1964. At its peak, the Station employed over 6,500 men working round-the-clock, seven days a week. Now that the station is fully operational, it is manned by an operating and maintenance staff of 250 only and operated round-the-clock.

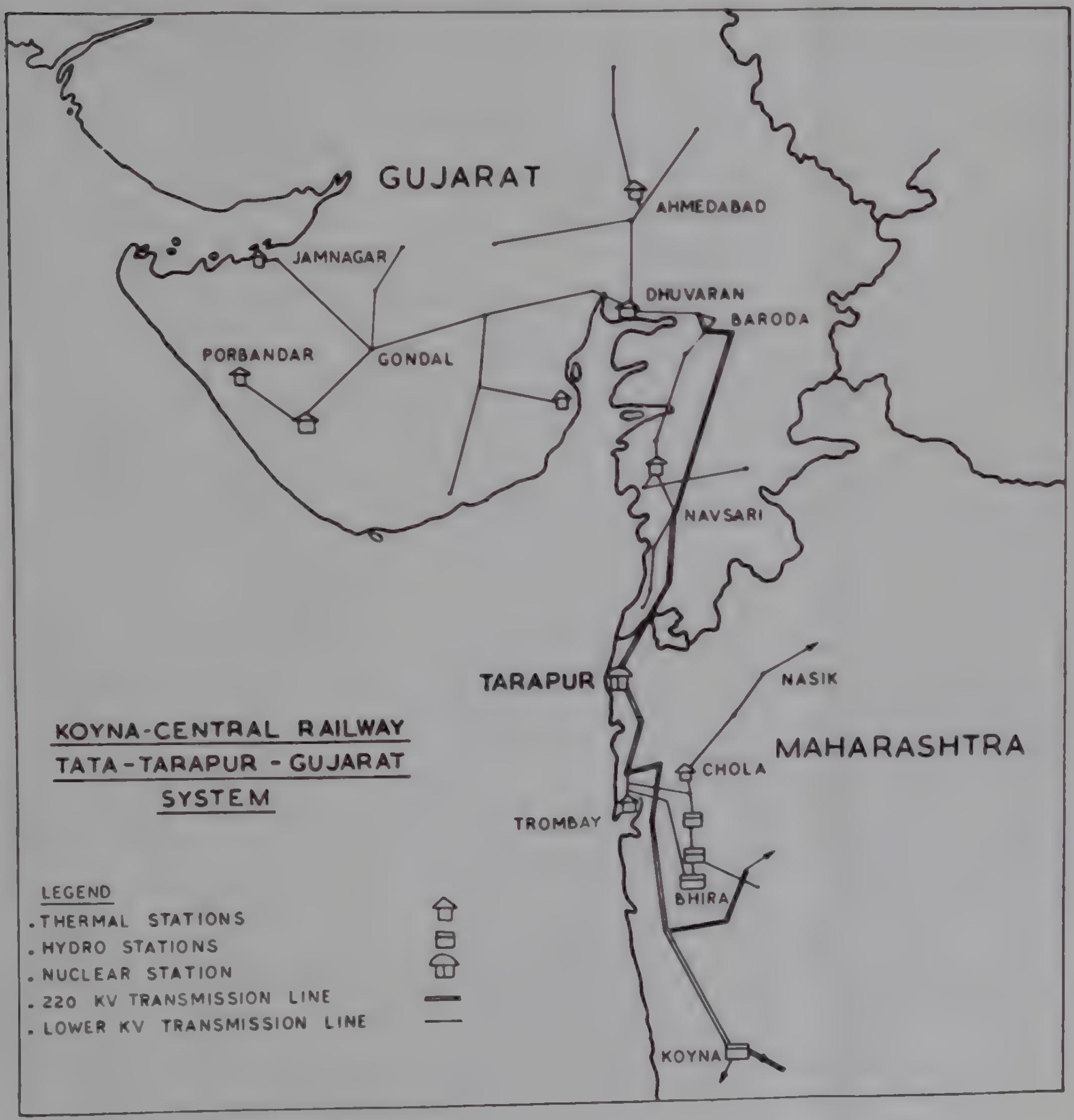
The Station consists of two Boiling Water type reactors, each helping generate over 200 MWe. Heat created by the fission of uranium atoms boils water in the reactor core and the steam rising up is led under pressure, after drying, to the turbine which is coupled to a generator. The total power generated is well over 400 MWe out of which 20 MWe will be consumed at the project itself while 380 MWe will be fed into the inter-State grid. The electrical grid system in the western region of the two States have been integrated through the switchyard at the Tarapur station and the combined grid has a capacity of about 2,300 MW.

Fuel is transferred to and from the reactors under water, through an adjacent storage pool. The irradiated fuel residue will be reprocessed in a Reprocessing Plant that is being built at the site. This plant, being put up by the Bhabha Atomic Research Centre, will extract plutonium and residual uranium. When the technology of using plutonium in power reactors is perfected, the station should be able to operate on plutonium fuel wholly or partially, thus reducing the need for importing enriched uranium.

The life of the Station is usually taken as 25 years. Initially 40 tonnes of enriched uranium was fed to each reactor. No fresh fuel is required for two years. After that, both the reactors will together require about 20 tonnes per annum. Though fuel elements have been supplied by the U.S. for the first charge, in future, fuel will be fabricated in India itself out of the enriched uranium which will be imported from the United States.

One of the important considerations while setting up a nuclear power plant is safety. Apart from taking the first precaution of locating the plant away from a large town, a series of safety features have been built into the Tarapur plant system itself for arresting even infinitesmal degrees of radioactivity. This has been done by making the plant walls of thick reinforcement concrete and enclosing the reactors separately inside a shell of steel (drywell), each with a pressure supressing pool of water. In addition, exhausts are continuously monitored for radioactivity and are released into the atmosphere from a 112-metre-high stack. Data on environmental and dietetic radioactivity in the area has been collected over the past four years and the function is continuing.

ing nuclear power station in Asia, American and Indian engineers and technicians have worked shoulder to shoulder on almost all aspects of the job. Indian project personnel have participated fully at every stage in giving shape to the Station — from drawing up specifications, reviewing and improving designs, supervising erection, to the testing and commissioning of different units of the complex. Besides the services of the consultant's experts and the project staff themselves, specialist advice was made available by the Bhabha Atomic Research Centre at Trombay. Special mention must be made of the assistance extended to the Project by the U.S. Atomic Energy Commission which off and on readily provided technical advice whenever approached, thus greatly helping in building up the Project staff's confidence in this highly specialized field. ●



Man's Expanding Power Demands Re-Adjustment in Thinking, Attitudes

(*Continued from page* 5)

single direction in which he has moved during the last few centuries" and from this he draws the conclusion "that human capacity for observation and judgement has its limits". But why need it remain so? Can we at this exciting phase of development lose our initiative and our faith in ourselves? Can we allow our destiny to be shaped by impersonal forces? Man's sensitivity to evil has increased and, for the first time, these matters are being discussed not by a few philosophers but by large numbers of people and specially the young all over the world. Man has always aspired to surpass himself. Surely, development in one direction does not preclude the future possibility of exploration and evolution in other directions. But for this to come about, there must be a conscious effort far greater than ever made before, for such development may well mean a fundamental change in the very nature of man. The gains will not be the familiar and tangible ones in terms of material goods but the deeper, more satisfying ones of understanding and compassion. If any item of consumption is in short supply, what is there to prevent us from replacing it or adapting ourselves to something different?

From this viewpoint, the future becomes one of vast potential. And if this is possible, it means that no one need fight or compete with another for the sharing of limited resources.

Welfare of Mankind

Man's expanding knowledge and power render largely obsolete, the scarcity logic on which much of the world's planning and programming are based. Today, we can undertake undreamt of tasks. Can we then afford to live or think in compartments and to function within the limits of narrow specialisation? The greatest need is for a comprehensive readjustment of our thinking and our attitudes. We must break the many artificial barriers which separate man from man. We must strive to build a way of life which treats all men whatever their race, religion or caste, with dignity and respect. We must be committed to the welfare of all mankind. Is there a conflict between realism and idealism? Can there be a long term realistic picture of the world which is not based on idealism?

This formal dedication ceremony is taking place in the first month of a new decade. May I express the wish that this decade brings progress for India in the long battle against poverty. May I also wish that this and the coming decades will not witness, in any part of the world, the use of atomic energy for destruction. Let us assert the force of man's spirit which is unconquerable. ●

Health Physics in the Tarapu

Safety at the Tarapur Atomic Power Station is the responsibility of the Bhabha Atomic Research Centre, Trombay. The Health Physics Division of the Centre manages a unique programme to monitor radioactivity and protect the population living in the vicinity from undue exposures to radiation. The work of the Health Physicists provides for evolving safe siting criteria and site selection, analysis of designs and operational procedures with reference to safety, and finally, provides expert radiation protection surveillance and advice. In this brief article the work of the Health Physics team at Tarapur is described in two parts: Inplant Health Physics control, and environmental surveillance.

SAFETY in relation to nuclear energy has a deep significance. It means not only safety of personnel in a nuclear installation but also the inhabitants, and animal and vegetable life in its environment. When a nuclear installation is set up therefore, not only must safety features be incorporated into it for the personnel, but also for the protection of life miles around.

The major hazard from a nuclear installation is radiation. The main safeguard is to restrict exposure of personnel and strictly control release of radioactive material into the environment.

Radiation is a natural phenomenon. When a nuclear installation is set up however, care has to be taken to ensure that it does not add to the normal radioactivity present in the atmosphere. For this purpose, health physicists study and measure radioactivity levels in the area over a length of time some years before start of work on a nuclear plant.

The twin goals of providing economically competitive and reliable power without disturbing the quality of the environment is being met at the first atomic power station in the country.

Pre-Operational Study

Nuclear technology has been almost unique in safety planning and efforts that have gone into providing for public safety. That Tarapur has been no exception has been demonstrated amply by its safe operating record so far.

At Tarapur, survey and study of the environment began much before the commencement of work on the Station itself. In a way the safety team there grew with the Station. By the time the Station commenced operation, the team was in a position to attend to problems in power reactor safety management.

An Environmental Survey Laboratory (ESL) was set up at Tarapur in December 1964 by the Health Physics Division of the Bhabha Atomic Research Centre, Trombay, for investigating environmental radioactivity in the pre-operational period, to keep check on possible radioactivity pollution of the environment due to power reactor operation, and to advise the power plant on levels of radioactivity in the environment.

In the six years of work at the ESL, in the pre-operational phase, efforts were made to acquire a thorough understanding of the relationship between the Tarapur environment and the people living there. About 1,800 samples of environmental material and products like soil, water, air, crops, vegetables, fruits, grass, milk, fish etc. were collected from a 32 km. area around the site and analysed for natural and artificial radioactivity and important trace elements. Seasonal fluctuations of radioactivity in the samples were noted. The radioactivity levels in the samples during the pre-operational phase form the norm for reference during operation of reactors. The study of radioactivity and trace element distribution in the various environmental samples has led to identification of indicator samples for different radioactive pollutants. For example, goat thyroid is an indicator of radioiodine present in grass; sea-weed of radioiodine in sea water; oysters and lobsters for activation products in sea; spinach and betel leaf for radioiron and radio-strontium deposition. These are some of the useful indicator units in the Tarapur environment.

Permanent Stations

The Laboratory also collected data on population distribution, dietary and local habits of people, food production from land and marine sources, land utilization, nature of soil and ground water, and coastal water movement near reactor site. From these, permanent and continual monitoring stations in the environment have been fixed up so as to easily detect any hazardous contamination due to reactor operation.

It is essential to identify the path of reactor-released radioactivity reaching man and also the group of population (critical group) which is likely to be effected to the maximum from reactor releases. For this purpose, ESL carried out a systematic diet survey during 1966 and 1967 at Tarapur. Daily per capita consumption of dietary components and radioactivity and trace element content of these diet components were determined. This has indicated how Indian diet differs from Western diet in radioactivity content. The diet study has shown that for Tarapur, fishermen form the critical group of population, and fish is the critical food material.

Soil-Plant Relationship

Very close to the reactor site, the Laboratory operates a farm where vegetables and food crops are grown. In the preoperational period, a study of radioactivity fallout pick-up by paddy during different stages of growth of the plant was carried out. Soil-plant relationship to fallout activity for many of the common vegetables were investigated in this farm. Work will be continued to detect increases in radioactivity in vegetables due to the operation of the Reactor, and the Fuel Reprocessing Plant which is being built at Tarapur. The Laboratory has evaluated the maximum permissible concentration (MPC) of radionuclides in the environmental components. This is based on the dietary intake through the food components by man, and concentration factors for the radionuclides in each step of exposure pathways. For example, the maximum permissible concentration in sea water at Tarapur for different radioisotopes is

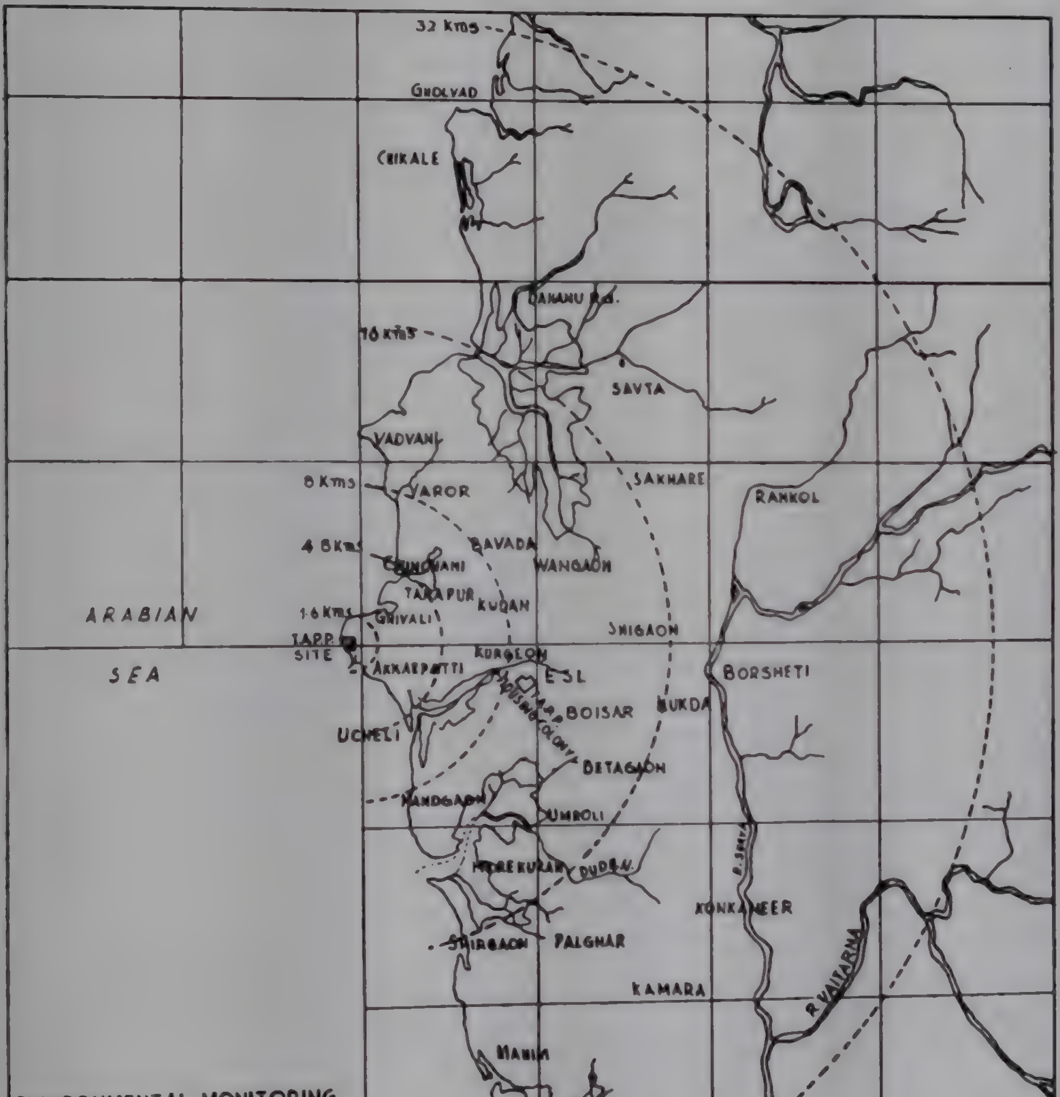
nvironment

By I. S. Bhat and P. Abraham,
Health Physics Division, Bhabha Atomic Research Centre

evaluated on the basis of fish and salt (produced from sea water) consumption by the population, and the concentration factor for the radionuclides from sea water to fish. These derived MPCs are characteristic of this environment and may not be the same for other places.

The Tarapur station discharges low-level radioactive wastes into the sea through discharge canals along the coast. For predicting the movement of discharged waste and to evaluate the dilution factor available for discharged activity, mixing characteristics of coastal waters near the site were investigated experimentally by discharging Rhodamine B dye and bottle floats. The dye discharge was carried out during different tidal conditions and concentrations at various locations. On shore and off-shore measurements have been made using a fluorimeter. Observations have shown that under any tidal condition, the discharged dye solution oscillates along the coast near the discharge site. The lateral mixing with off-shore sea water is slow. From the dilution of discharged dye, dilution factors for single and continuous discharge from reactors were evaluated.

32 km region under radiation surveillance at Tarapur.


32 kms
GHOLVAD
CHIKALE
DAHANU Rd.
16 kms
SAVTA
VADVANI
8 Kms
VAROR
SAKHARE
RANKOL
4.8 Kms
CHINCHANI
BAVADA
WANGAON
TARAPUR
KUDAN
ARABIAN
SEA
1.6 Kms
GHIVALI
TAPP SITE
SHIGAON
AKKARPATTI
KURGAON
ESL
BORSHETI
BOISAR
BUKDA
UCHELI
BETAGAON
NANDGAON
UMROLI
DUDELI
KONKANEER
SHIRGAON
PALGHAR
KAMARA
R. VAITARNA
MAHIM
TANDULWADI
MAKUNSAR
ENVIRONMENTAL MONITORING STATIONS, T.A.P.P.

Besides environmental survey and measurement, the Health Physics team is responsible for ensuring safety of personnel in the station. With this object in view the team makes radiation and radioactive contamination measurements in the different areas of the station, gives on-the-spot advice to the personnel on use of protective clothing, prescribes time limits for working in radiation areas and advises on safety aspects of station operation.

Detailed radiation surveys were conducted at all locations in the Station during the criticality and low-power tests and for the step-by-step increase in reactor power level to test the radiation shielding installed in the plant. To facilitate planning of radiation work, the team routinely takes radiation measurements at specific locations. Procedural controls enforced at the station stipulate that all jobs involving radiation and radioactive materials are planned and undertaken only after Health Physics clearance is obtained. The radiation exposure and radioactive contamination of Station personnel is controlled by this procedure. The layout of the Station is such that all personnel entering any potentially radioactive area have to pass through the "change room" located near the Health Physics Office, which is manned round the clock by health surveyors. An access control log is also maintained in the Health Physics Office to indicate the names of persons working in the controlled areas and the jobs they are doing.

Release of Radioactivity

A close watch is also maintained on the management and disposal into the environment of the solid, liquid and gaseous radioactive wastes arising from the operation of the Station. Three environmental monitoring stations are located strategically around the power station and equipped with very sensitive radiation measuring instruments.

(Continued on next page)

Constant Radioactivity Monitoring at Tarapur

They have not so far detected any increase due to the operation of the Tarapur Station in the normal background radiation which, incidentally, is about 100 millirems per year.

The release of radioactivity into the discharge canal, monitored continuously has been only about 30% of the permissible discharge limit of 10^{-7} μ c/ml for an unidentified mixture of radioisotopes, in the case of drinking water. The gaseous radioactive effluent is released to the atmosphere through the 112-metre stack to provide dilution before reaching ground level. The annual average stack release rate, calculated on the basis of actual meteorological data from Tarapur is 580 millicuries per second. This release rate is expected to give a maximum annual radiation dose of 500 millirems to the station environs at a distance of 1 km ENE of the stack. (500 mrems is the permissible annual radiation dose to the environs of a nuclear plant, as recommended by the International Commission on Radiological Protection (ICRP). The actual gaseous discharge from Tarapur has so far been wellbelow the annual average release rate.

Constant Vigil

Liquid waste with low-level radioactivity is being discharged into the sea since February 1969. This waste mainly contains activation products like radio-cobalt and radio-manganese etc. The Environmental Survey Lab keeps a constant watch on the levels of activity in sea water at site. It has been observed that most of the discharged activity is picked up by the silt and slowly deposited on the sea bed. Silt, sea water, sea weed and fish samples from various locations along north and south sides of the coast along the site are regularly collected every month to find out the spread of this incharged radioactivity. The levels of activity in the marine environment at present due to reactor discharges are well below the permissible concentrations.

Body Contamination

Environmental emergency conditions may arise in reactor site due to accidents. To cope with any possible accident conditions, ESL has planned an emergency monitoring system. An environmental survey vehicle has been fitted with equipment like air samplers, survey meters, beta gamma counting systems and sampling bags and bottles. Immediate measures to be taken up have been envisaged for radiation safety of the affected population.

Well Equipped Lab.

The radiation workers at the site need constant check-up on the internal body contamination by radionuclides. For this purpose the laboratory has examined the urine samples of staff working at site for radioactivity in the preoperational stage, and this will be repeated periodically to observe body contamination of workers during reactor operation.

The laboratory is equipped with a whole body monitor to measure the body radioactivity of radiation workers. The equipment has been used in monitoring Tarapur staff as well as members of the public. It has been found very useful to estimate activation products inside the body due to accidental internal exposure at Tarapur Station.

The laboratory's small team of four scientists is on constant vigil on the safety of the environment and the general public at the reactor site.

The radiation safety programme at the Station has so far produced very good results as is indicated from the radiation exposure record of the station personnel. The average radiation exposure of the personnel during the commissioning stage, lasting about nine months, has been only 65 millirems. This average works out to only about 1.7 per cent of the permissible limits established by the International Commission on Radiological Protection (ICRP) for radiation workers. In no case was the quarterly or yearly limit exceeded. ●

(Continued from page 3)

kilowatt hours will flow in equal proportions into the Grids of Maharashtra and Gujarat States and will contribute in a great measure to the development of industry and agriculture in the region. The successful commissioning of this great Project called for solutions to very difficult problems. I congratulate the large number of engineers and workers who participated in this momentous task of successfully completing India's first Nuclear Power Project in co-operation with engineers of the International General Electric Co. of U.S.A. The experience so gained would, I am sure, serve as a source of inspiration and renewed confidence to Indian engineers and scientists in implementing other Atomic Power Projects which are under execution in the country.

Mr. Ramey's Address

(Continued from page 5)

with the U.S. Atomic Energy Commission which I have had the privilege of developing with Dr. Sarabhai are playing a major role. U.S. AEC's Oak Ridge National Laboratory is actively cooperating in this programme, as is the Tennessee Valley Authority which has a great deal of experience in large regional undertakings.

Our two Atomic Energy Commissions are also cooperating closely on a study of the future for nuclear power in India with special emphasis on the utilisation of thorium, of which India's vast reserves are the world's largest.

The possibilities I have cited are only examples of the exciting promise which nuclear power holds for India's national development. ●

Seminar on Nuclear Power

J decade ago, when nuclear technology was still in its infancy, Dr. Homi Bhabha had underlined the need for atomic energy in developing countries, refuting suggestions from some quarters that such nations would benefit from it only after proceeding with industrialization on conventional lines.

On January 17 and 18, nearly 1,000 scientists, engineers, industrialists and government officials met at the Tata Institute of Fundamental Research, Bombay, to review the progress made in the utilization of atomic power in the world, particularly in India in the light of Dr. Bhabha's philosophy.

The Seminar was organized by the Department of Atomic Energy to coincide with the dedication celebrations of Tarapur. It showed that progress made so far vindicates Dr. Homi Bhabha's forward looking steps taken years back when not many countries were sure of the development of nuclear power.

Twenty papers were discussed at the Seminar which had among its participants Dr. Sigvard Eklund, Director General of the IAEA and representatives from Canada, France, West Germany, Italy, Sweden, USA, UK besides India the host country.

Agro-Industrial Complex In the Gangetic Plain

Dr. Vikram A. Sarabhai, Chairman AEC, and Shri K. T. Thomas and Shri M. P. S. Ramani of the Bhabha Atomic Research Centre, in a joint paper, outlined a scheme for a nuclear-powered agro-industrial complex in the Gangetic Plain. In terms of a per capita power consumption of 66.17 KWh/annum, India occupies the 113th position in the world. Because of her sheer size however, they maintained that she was in an unique position to utilize the benefits of atomic power. With an installed power generating capacity of 9,700 MWe in 1966, India had the 14th largest power system in the world, and the largest among the developing countries. They held that since its doubling time is about seven years, any decision concerning a new generating plant taken now should be in relation to its size by 1975. The authors maintained that a national figure of about 25,000 MW, made up of four regional grids of 6,000 MW each should be considered. Because of this, India had options in regard to the size of its power stations and technologies adopted, which are not generally available to developing countries.

The proposed nuclear powered agro-industrial complex would cover three divisions of Agra, Meerut and Rohilkhand in Uttar Pradesh. Their report showed that a project involving about Rs. 1,200 crores in the region would give a return on investment of the order of more than 65% per annum. The authors preliminary findings show that low-cost nuclear energy can be used for the production of aluminium, for providing water for irrigation either by desalination or by energizing tube wells and, ultimately for cultivating food crops.

Reverse Osmosis for Desalting

Dr. C. M. Wong, Director, Office of Saline Water, U.S. Department of the Interior, detailed the findings of a research programme for development of new or improved processes for low-cost desalination of sea or brackish waters. When the U.S. desalting programme began, he said, there were only a few small land-based plants scattered around the world, in remote arid areas. The cost of water produced by these plants was high, ranging upward from $4 per 1000 gallons. Today, he said, there were approximately 700 desalting plants producing about 300 million gallons of fresh water per day. By 1975 he said the world-wide desalting capacity could exceed one billion gallons per day.

Most of the plants now under construction he said, utilized the multi-stage flash distillation process, and one large commercial desalting plant (one million gpd) was utilizing the vertical tube evaporator process. A number of smaller plants use a vapour compression cycle. The next generation of desalting plants would probably use a combination of multi-stage flash and vertical tube evaporators, and for some uses perhaps a combination of all three, with the vapour compressions supplied by jet turbines.

Distillation plants of course require heat energy. Dr. Wong said that the multi-million gallons per day desalting plants expected to be constructed during this decade would be one part of a dual purpose facility designed to produce both electricity and fresh water with the energy supplied by nuclear reactors. He maintained that the demand for heat energy from nuclear reactors for desalting plants would be second only to the demand for energy to generate electric power.

Dr. Wong disclosed that the United States was working on the development of two principal types of membrane processes: electrodialysis and reverse osmosis. Electrodialysis uses a combination of anion and cation membranes and an electric current to remove the dissolved salts from water. Reverse osmosis uses a cellulose acetate base membrane and hydraulic pressure to desalt saline waters. At the present time, these processes have their greatest potential for producing fresh water from brackish water supplies, that is, from inland saline waters that contain far less dissolved salts than sea water.

Dr. K. Channabasappa, also of the U.S. Office of Saline Water, spoke on the reverse osmosis process as a water supply system. He said the process was particularly attractive for India because of its simplicity—simplicity of both equipment, construction and operation. The process requires very few components, most of which can be readily manufactured with local materials and manpower.

Role of Nuclear Energy in the Indian National Grid

Messrs. H. Kramer, K. Wagemann, and A. Boettcher reported on their investigations on the future role of nuclear energy in the Indian National Grid. With an optimization computer programme they analysed several po-

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Stage Set for Taking Up Difficult Challenges

wer systems with different nuclear and conventional plants under conditions of the Indian grid systems. Their main findings are: Heavy Water Reactors would probably give the best starting conditions for the planned Indian nuclear power generating system. Light Water Reactors could reduce the power generating cost slightly but they would increase the necessary foreign exchange due to higher uranium requirements and separative work. If the Indian nuclear power programme was based only on local reserves of natural uranium, this would lead to a rather restricted Heavy Water Reactor capacity (max. 10,000 MWe). In this case, nuclear energy would probably play no significant role within a long term consideration even if high performance breeders are introduced to the grid. They stressed that the uranium stockpile available for the Indian grid systems should get highest priority. With uranium reserves of 250,000 tons which cost about $4 billion, the power generating cost could be reduced by about $30 billion within the next 30 years. At the same time, the potential of Fast Breeders could be increased drastically, which would certainly facilitate the problems of long-term power supply. They held that when optimising the grid under the specific Indian conditions over a time period which is not longer than 30 to 40 years, advanced thermal nuclear concepts as the MSBR, the HTR and the thorium-HWR could have a good chance besides the reference concepts. They could lead to considerable savings in power generating costs as well as in foreign exchange requirements.

Optimum Utilization of Nuclear Resources

Dr. B. D. Nag Choudhary, Member, Planning Commission, speaking on the Future of Atomic Power, pointed out that programmes should be initiated towards development of those advanced reactor concepts which ensure an optimum utilization of India's resources of both fissile and fertile materials.

He said the initial stage of building up confidence was over and India had reached a stage when confidence already established could be tested and made really firm by accepting the more difficult challenges with which it was now faced. The most difficult challenge he visualized was the attempt to leapfrog into the range of viable atomic power programme within the next 20 or 25 years. This would mean taking up right now various types of work in connection with breeding, liquid metal coolants, ceramic fuels, enrichment, more sophisticated instrumentation including sophisticated process control instrumentation etc. The advantages of such an attempt to leapfrog is that there could be an increase in the employment of scientists and technologists in the country, even today without substantially increasing investment.

Commissioner James T. Ramey reviewed the present status and prospects for nuclear power in the United States, and discussed the efforts being made on advanced reactors, desalting technology, and energy centers in his country.

Experience at Kalpakkam

Dr. M. R. Srinivasan, Chief Construction Engineer of the Madras Atomic Power Project described progress, and problems, of construction at Kalpakkam where India's third atomic power plant is coming up. He said that though the basic features of the Kalpakkam plant would be the same as of Rajasthan, a number of changes were being incorporated for reasons of economics and to suit local conditions. He outlined certain features of construction at Kalpakkam on the conventional side of the plant which merit special mention. For example, the shore line on the eastern sea coast of India is subjected to heavy littoral drift and is also visited by cyclones of high intensity more or less regularly. This he said had necessitated the adoption of submarine tunnel for drawing the cooling water for the condensers and the construction of an approach jetty extending about 500 meters into the open sea in order to facilitate the construction of the intake structure and also enable its maintenance. The existance of a high subsoil water table has dictated choice of the continuous cast diaphragm wall technique for a number of sub-structures of the power station. So far as the equipment is concerned, most of it, both nuclear and non-nuclear is being contracted out to industry in India he said.

Large Scale Nuclear Development Programme Necessary

Shri K. L. Vij, Chairman, Power Economy Committee, India, in his paper, "Planning for Nuclear Power Development", reviewed the present position and future requirements of energy and electricity in India vis-a-vis the advanced countries. He pointed out that in order to attain a reasonable minimum standard of energy utilization, a large scale programme of nuclear power development would be necessary on a long term basis in view of the limited solid and petroleum fuels in the country. He stressed that substantial economies in nuclear power generation could be derived by adopting larger unit sizes. But this would require closer integration of regional power systems, and necessary facilities for the same should be built up. He advised that peaking capacity through conventional hydro and pumped storage schemes should be built up for complementary operation with nuclear power stations.

In a joint paper titled "A Mix Optimization Model and its Application to the Northern Grid," S/s. R. Narasimhan and N. Seshagiri of the Tata Institute of Fundamental Research and Shri M. N. Chakravarti and S. S. Shiralkar of the Department of Atomic Energy said that a proper choice of the type of power plant for a given region and the extent of investment that can be made during a specified period of time is of much

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Series of Rocket Launchings at Thumba Station

THERE has been a spurt in rocket launchings from the Thumba Equatorial Rocket Launching Station (TERLS). Currently two series of launchings are taking place under separate agreements—one with NASA and the other with the British Meteorological Office.

Under a joint collaborative programme between the Indian Space Research Organization (ISRO), and the National Aeronautics and Space Administration (NASA) of the USA, 11 rockets with scientific payloads will be launched. The programme began with the launching on March 9 of three Nike-Tomahawk rockets for investigating inter-relations among ion composition, air glow emissions and vertical drift velocities in the E and F regions of the atmosphere. These rockets are capable of reaching an altitude of 324 km when launched at 86° elevation with a payload of 63 kg. This was followed by the launching of three Nike-Apache rockets with NASA payload on March 19. Two of the rockets with 58 kg. payload reached an altitude of 120 km while the third with 27 kg payload went upto 195 km. All the experiments were successfully completed by March 27. Valuable data was received from rocket-borne payload.

ISRO Payload

The Nike-Apache rockets were launched for day-time investigation of the lower ionosphere. These rockets reach altitudes between 125 km and 170 km with varying payloads. For one of these experiments, the payload — consisting of magnetometer, Langmuir Probe, telemetry instrumentation and other hardware, has been prepared by ISRO scientists. The Indian scientists are also providing ground-based support including ionosphere measurements, ionosphere drifts, magnetometer and measurement of air glow emissions.

Nike–Tomahawk being readied for launching. *Below*, Skua rocket on the launcher.

Four Arcas rockets are also to be launched soon for measurements in the D region. These rockets will reach altitudes of 90 km with 6 kg. payload.

Under the collaboration programme between the Indian Space Research

(Continued on page 2)

Spurt in TERLS Rocket Launchings

Organisation of the Department of Atomic Energy, and the British Meteorological Office (BMO) of the U.K., launching of Skua rockets with meteorological payloads began at TERLS on March 4. In all ten Skua rockets will be launched.

The purpose of the experiment is to obtain wind and temperature data of the neutral atmosphere from 70 km downwards. An instrumented payload weighing 5 kg. will be carried by a Skua rocket and ejected at 70 km. altitude. The payload will be gently brought down by a parachute. The drift of the parachute provides information for determining wind direction. Temperature data is transmitted to ground equipment. The launchings are made soon after sunset.

Petrel Rocket

The Department of Atomic Energy and the UK Science Research Council have agreed to conduct collaborative experiments for the investigation of positive ion density measurements in the D region of the ionosphere, using Skua II (T) rockets, and the equatorial electrojet by magnetometer measurements on the ground, and in Petrel rockets. The Skua rockets will reach 105 km altitude with a payload of 5.7 kg. The Petrel rockets will reach 135 km with 15 kg of payload. The rockets and payload will be supplied by the United Kingdom.

The first Skua rocket carrying cylindrical probe payload for investigation of the D-region was successfully launched from Thumba at 1405 hours IST on February 18, 1970. The rocket and payload performance was very good. The ground telemetry received good signals until splash at 320 seconds. The radar tracked for 50 km from take-off.

The rocket and the payload for the experiment were supplied by the Science Research Council of the U.K. and the payload integration, check-out, launching and tracking were carried out by TERLS. This is the first of a series of rockets proposed to be launched from Thumba under U.K.-India collaboration in Space Research. The Petrel rockets will be launched by the end of this year. ●

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Indian Vacuum Society Formed in Bombay

A new professional organization, the Indian Vacuum Society, came into being in Bombay on February 14 with its formal inauguration at the Victoria Jubilee Technical Institute, Bombay, by Shri H. N. Sethna, Director of the Bhabha Atomic Research Centre, Trombay.

The Society seeks to further vacuum technology and encourage the growing interest in the country in its varied applications.

Inaugurating the Society, Shri Sethna said he disagreed with the view held in some advanced countries that the best way to close the technological gap in developing nations was to import new technology. He said that as technology aged at a rapid rate, its mere import without building a strong research and development base would make the importing nation perpetually dependent. Import of technology he said must be done on an extremely selective basis — indiscriminate import, specially by poor countries like India, should be avoided.

An exhibition of Vacuum Equipment was held on the occasion. ●

BARC Reporting

Directorate of Radiation Protection

The film badge service covered a total of 8,900 workers from 1,087 institutions all over the country during February 10 — March 15.

Isotope Division

The sale value of radioisotopes, equipment and services rendered during February 15—March 10, totalled Rs. 1.4 lakhs. A total of 1,759 consignments including 1,016 for medical use were supplied during this period

A total of 540 consignments valued at Rs. 10,100 were exported to Australia, Ceylon, Denmark, France, Sweden, Thailand and the U.A.R.

Electronics Division

A two-parameter system based on 400 and 1024 channel analyser with inter-face has been designed and engineered. The two analysers can also be used independently as they contain independent CRT display and memory elements.

The new system consisting of two analysers with inter-face programmer is much more superior to a conventional two single parameter system as it offers digitally selectable window with flexible width on the 400 channel analyser which can be used to route the coincidence events to pre-assigned memory sub-groups of 1024 channel analyser where the distribution within the sub-group is analysed and stored.

The combined system on 1024 channel can be used as two parameter with 512 channel, four parameter with 256 channel and sight parameter with 1024 channel. The system under fabrication is likely to be ready for operational tests by end of June 1970.

Microwave Technology Symposium at TIFR

A three-day Symposium on Electronics (Microwave Technology) was held at the Tata Institute of Fundamental Research, Bombay during February 25-27. Organized by the Committee on Electronics, Board of Research for Nuclear Science, Department of Atomic Energy, the symposium was attended by about 100 delegates from research and user institutions and organisations in the country including the Ministries of Railways and Defence, the Directorate of Civil Aviation, the National Physical Laboratory, Delhi, the Central Electronics Research Institute, Pilani, the Tata Institute of Fundamental Research, Bombay, the Physical Research Laboratory, Ahmedabad, the Space Science and Technology Centre, Thumba and the Bhabha Atomic Research Centre, Trombay.

The Symposium set as its objectives the following: (a) to survey the state of microwave electronics in India, (b) review developmental activities in various connected institutions in the country, (c) evolve guidelines for immediate as well as long term research and development, and (d) focus attention on organisational and funding problems as well as feedback between academic institutions and R & D units within and outside the Department of Atomic Energy.

No Restrictions

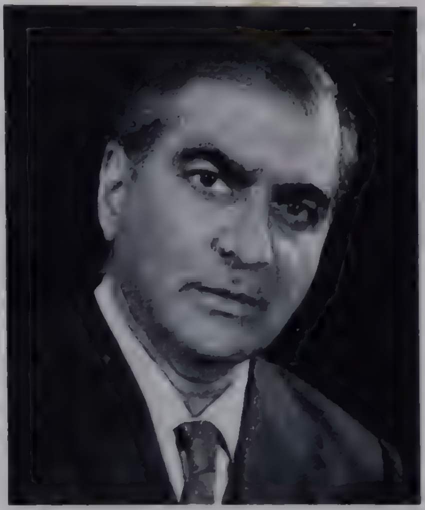
Inaugurating the Symposium, Prof. M. G. K. Menon, FRS, Director of TIFR said that development and production activity in electronics should be organised in an integral and interlocked manner, without rectrictions of civilian or military use and private or public sector production.

Production activity in electronics he said should be based only on economic and technological considerations as done in highly industrialised countries. He pointed out that security considerations did not require even such countries to separate civilian and defence production.

Continuing, Prof. Menon said that a strong feeling existed in India that electronics was primarily a production activity and that all work in the area should necessarily have immediate applications and production capabilities. In India also, he said, there should be long range research not directly related to immediate applications. Particularly strong support should be given to advanced study in solid state research as also to research workers who have proved their capabilities.

Earlier, welcoming the delegates on behalf of the Committee for Electronics, Prof. G. K. Bhagwat of I.I.T., Powai, stressed the increasing role of microwave technology and of electronics in general in the present space age. Prof. Bhagwat referred to the work being done by the P & T, the Railways and other organisations, and made a strong plea for an integrated approach to the development of microwave technology in India. ●

University of Mysore Honours Distinguished BARC Scientist



Dr. A. R. Gopal-Ayengar, Director of the Bio-Medical Group at the Bhabha Atomic Research Centre, Trombay, was honoured by the University of Mysore at its 50th Annual Convocation on January 27 with the degree of Doctor of Science (Honoris Causa) in recognition of his contribution to Radiation Biology and Radiation Genetics.

The Bio-Medical Group of the Bhabha Centre is engaged in research relating to applications of radiation for crop improvement, food preservation and insect sterilization by ionising radiations, human chromosome studies, genetical and biological investigation in high background radiation areas in India and other cognate disciplines of radiation biology and radiation genetics.

This distinguished scientist is the recepient of many national and international awards. In 1967 he received the Padma Shri. Earlier he was awarded the Vincent Massey Fellowship and the Elizabeth Ann Wintercorbyn Award of the University of Toronto, the J. H. Bhabha prize for original work in cytology and the International Lady Tata Award. In 1966 he was among the "five selected scientists of world distinction" in the words of the International Atomic Energy Agency who were invited by it to deliver special lectures at its 10th Commemoration function. The other speakers being outstanding scientists from the United Kingdom, U.S.A., the U.S.S.R. and France. He was formerly Chairman of the 15-Nation United Nations Scientific Committee on the Effects of Atomic Radiation, and continues as Representative of India on the Committee. The Director was also the first President of the International Commission on Radiation Biophysics of the International Union for Pure and Applied Biophysics.

Dr. Gopal-Ayengar is a Member of the Boards of Studies in Bio-Sciences of the Universities of Bombay, Poona, Baroda, Karnatak, Kerala and Mysore and an Honorary Professor of Cell Biology of the University of Madurai.

Currents in Bio-Information Research

by **Dr. A. Sreenivasan**
Bhabha Atomic Research Centre, Trombay.

MAN has now built up a certain degree of confidence that he would be able to explain the whole biology in terms of physico-chemical principles. The revolution in Physics in the mid-Twenties provided a sound theoretical basis for Chemistry and this, in turn, has provided us with a foundation of certainty for erecting the structure for Biology. There is now much basis for considering life as a physical state in which matter and energy interact as in other physical states. It is a state characterised by phenomena involving remarkable organisational complexity. The unique structure of living things depends on the existence of particularly large complex molecules and unique supramolecular arrangements. Specialised mechanisms of energy generation and utilisation exist for their syntheses and orderly function. Perpetuation of the living state depends on the maintenance of this organisation and on special replicative mechanisms.

Early Developments

The biologists' quest into the mechanics of hereditary information transfer has passed through several phases. From Mendelian times, he had worked out various ground rules for the continuance of traits which enabled him to explain many curious phenomena of inheritance. Later emphasis was on material basis of heredity, *i.e.*, the involvement of genes and chromosomes in the transfer of bio-information. In modern genetics, the feature that has proved of great significance has been an intensive concentration of research efforts on a few special organisms from the immense variety available to us in nature. Most of the researches resulting in important discoveries have been made with the bacterium *Escherichia coli*, so much so, it has sometimes been stated that, for the molecular biologist, the proper study of mankind is *E. coli*.

With *E. coli* and its phages as well as with fungi like *Neurospora*, new experimental approaches were made possible on gene action and on comparative studies of metabolic pathways. The early researches of Beadle and Tatum on *Neurospora* led to intermingling of the disciplines of Biochemistry and Genetics. The dictum 'one gene — one enzyme' — originating from these studies on *Neurospora* — can in fact be considered an important landmark in our researches to understand the chemical basis of heredity. The use of specific auxotrophic mutations as marker genes paved the way to the discoveries of new genetic systems with which detailed knowledge of linkage, of gene replication and recombination, and of chromosome passage in conjugation progressed at a very rapid pace. Other studies on induction, repression and feed-back inhibition soon led to important concepts on the regulation of gene activity.

We might say that the modern age of molecular genetics was conceived by the recognition of DNA as the genetic material and by the more germinal advance in this area on the double-helical structure of DNA proposed by Watson and Crick.

Concepts, Approaches, Discoveries

One obvious reason for the rapid strides in molecular biology is the comparative simplicity of the basic biological mechanisms and the fact that, with minor variations, they are the same throughout Nature: the genetic information is conveyed in the simple language

DNA → RNA → Protein.

Because traces of this simplicity could be seen at an early stage, it was possible to erect a theoretical scheme which has been of immense help in guiding experimentation. The main factor, therefore, for this phenomenal success has been the availability, in the last decade or two, of powerful experimental techniques which involve the application of physical or physical-chemical methods to biological molecules.

Thus, the technique of cesium chloride gradient centrifugation, together with isotope methodology, proved to be very fruitful in establishing that DNA replication is semi-conservative, as predicted from the Watson-Crick model. The technique of DNA melting or double strand separation and reconstitution on cooling, which is based on the concepts of H-binding in DNA double helices, has proved extremely valuable in ascertaining the binding of substances such as astinomycin D to DNA as well as in the detection, by hybridisation, of molecular homologies between different DNA molecules and between DNA and RNA. These principles have been effectively and ingeniously applied to determine molecular relationships between DNAs from different organisms as well as to detect differences in messenger RNAs.

More General Concept

The development of techniques of determining amino acid sequences in proteins and of the finger-printing technique of screening for peptide differences led, with human haemoglobin, to the first identification of a single amino acid substitution as the consequence of gene mutations.

Improvements in separation techniques have permitted demonstration that many enzymes exist in more than one form, as aggregates of several polypeptide monomers. This discovery, implicating different genetic sub-units or cistrons, has led to the replacement of the 'one gene—one enzyme' hypothesis by the more general concept of 'one cistron—one polypeptide chain'.

X-ray diffraction and electron microscope studies have aided in our knowledge of the elaborate three dimensional structures of several of the macromolecules.

Probably the most exciting and spectacular development in biochemistry during the last few years has been the elegant elucidation, experimentally, of the genetic code. Most of us, at one time, considered the direct experimental verification of the relation between DNA structure and protein structure to be many years away. It was thought that this would require the establishment, by methods yet to be developed, of complete amino acid sequences of proteins, as well as the isolation of single homogeneous gene DNA preparations with determination of their complete base sequences.

This route of attack was bypassed by major landmarks in experimentation such as the development of cell-free amino acid incorporating systems and the elucidation of the enzymatic mechanisms for DNA and RNA synthesis. Progress in establishing colinearity between gene structure and protein structure and in the complete deduction of the genetic code has been very largely dependent on the supply of synthetic nucleotides as became evident from the outstanding results of Khorana and his group.

Newer Knowledge

Our concepts of DNA replication, repair, transcription and translation, as also regulation of cellular processes are getting rapidly resolved — thanks to several ingenious approaches to these problems.

It is now realised that synthesis of DNA as it occurs in a cell cannot be completely described in terms of what we know of the enzymes involved in the *in vitro* DNA synthesis. We find, on the one hand, that purified enzymes, like DNA polymerase or DNA ligase, may be involved in hitherto unsuspected reactions and, on the other hand, that their catalytic properties can only partially explain processes occurring *in vivo*. The continued use of combinations of *in vivo* and *in vitro* analyses is necessary in order to obtain a total understanding of DNA metabolism.

"Through advances in biochemical genetics and nucleic acid and proteins chemistry, a comprehension of the most important properties of life heretofore puzzling and mysterious appears within our reach."

It is now considered that DNA synthesis in a bacterial cell begins at a specific origin, probably located at the cell membrane, and then proceeds sequentially until the terminus, close to the origin, is reached. Our expanding knowledge of the chemical and biological properties of cell membranes, the ability to isolate and characterise regulatory molecules, the availability of conditional lethal mutants deficient in DNA replication and the possibility of characterising allosteric changes in the polymerase, contribute to the optimistic view that the problem of regulation of DNA replication and other phenomena like recombination and repair will be solved within the next few years. Already there are efforts to understand mechanism of action of DNA polymerase. A model for an active centre of the *E. coli* enzyme, a single polypeptide chain of moderately high molecular weight, has been proposed by Kornberg which attempts to account for the various synthetic and degradative functions within the closely related sites in the active centre of the enzyme.

Recent findings have uncovered interesting facets of transcriptory processes or regulation of gene expression. It has been known for some time now that repressors, the products of regulator genes, which bind operators, are proteins. As it is known in the *lac operon* of *E. coli*, the controlling genetic elements are arranged in order as the *i* gene which specifies the repressor, then the promoter gene *p*, at which transcription is initiated, and then the operator site *o*, to which the repressor binds. Following these are the three structural genes of the *lac operon*. Largely as a result of researches in Beckwith's laboratory, we now know that *lac* repressor proteins can stop the progress of RNA polymerase molecules which are actively transcribing DNA.

"Many of the conveniences of modern life became possible because of the earlier advances in physics and chemistry, especially organic chemistry. In the same way we may hope to see, in the next decades, increasing applications of molecular biology to outstanding problems of human welfare."

Major Findings

The pace of research on factors which apparently regulate the specificity of RNA polymerase is accelerating. The excitement was sparked off at the beginning of this year when it was announced that pure *E. coli* RNA polymerase can apparently split into the minimal enzyme and an unsuspected component, now called the sigma factor. This sigma factor appears to be required for the enzyme to transcribe RNA from particular DNA templates. It is likely that there could be a whole series of specific factors, of which sigma is one, for determining the part of DNA being transcribed. In other words, the factors may determine which form of RNA molecules are actually manufactured in a cell, possibly by making otherwise inaccessible genes accessible to the minimal enzyme. More recent researches indicate that the sigma factor is necessary for initiation of RNA synthesis.

Many major findings have emerged from studies on acellular systems. The discovery of formyl-methionine transfer RNA has triggered a series of very ingenious experiments on initiation of protein synthesis. Efforts to assign function for nonsense triplet codons have resulted in much clearer understanding of the mechanism for termination of polypeptide synthesis. Vast information on the factors re-

(Continued from page 5)

Currents in Bio-Information Research

quired for initiation and elongation of polypeptide chain is now at hand and the role of GTP in these processes is fairly well defined.

Since the elucidation of the complete nucleotide sequence of alanyl-transfer RNA, structures of quite a few transfer RNAs are known. Some recent reports show that the double helical stem of a transfer RNA clover leaf is the region of this molecule required for specific recognition by the aminoacyl synthetase enzyme when it charges a t-RNA with the correct amino acid. It has been considered, for quite some time, that the anticodon site resides in one of the single-stranded loops of the molecule. The clue to unique functions of transfer RNA and initiator transfer RNA undoubtedly lies in the three-dimensional structure of the molecule. The independent discovery in several laboratories this year of methods of crystallising transfer RNA has signalled the start of a race to discover the secondary structure of t-RNA.

Growth in Higher Organism

The importance of structure of ribosomal sub-units in translation processes is now recognised. The cyclic dissociation and re-association of 30s and 50s ribosome sub-units during successive rounds of protein synthesis appears to be a universal process. It has been established that some of the protein components of the sub-units have important functions in the translation mechanism. There is undoubtedly an extraordinary degree of precision that is involved in the recognition mechanisms operating in the system.

One of the major areas of Biology now being infused with contemporary molecular genetic thought relates to growth and development in higher organisms. How does the single fertilised egg become differentiated during subsequent cell divisions into the diverse specialised tissues that constitute the adult organism?

A great deal of descriptive knowledge is already available on the changes exhibited by organisms during development and now, additionally, biochemical and genetical data are being applied to the problem.

A critical aspect of growth and development appears to involve turning on and turning off of certain genes in particular groups of cells at very specific times. The techniques and approaches that have been successful with micro-organisms are now being employed to determine whether and, even more importantly, how this is so. For example, do certain cells contain a unique assortment of mRNAs during a particular stage of development? Are there selective control mechanisms at other levels, such as the rate of mRNA destruction, the availability of ribosomes and the quantity, function, and specificity of certain types of transfer RNAs? We do not know whether what is already known about cellular regulatory mechanisms in microorganisms will also apply to higher organisms. And, once a parallel is found, we are still faced with the question whether the mechanism is important in differentiation and how it operates.

Structural Differences

We may expect some similarities between regulatory systems in micro-organisms and those in higher organisms and such systems could be important in guiding differentiation. However, although it is well-known that there are structural differences between chromosomes of bacteria and viruses and those of higher organisms, we do not as yet have a detailed picture of the structure of chromosomes of higher organisms and our understanding of how genic expression can be influenced and regulated is therefore necessarily limited.

The chromosomes of the higher organisms are associated with a variety of protein components and are surrounded by a nuclear membrane. Do these histones and non-histone proteins, play general or specific roles in gene action? For a number of years, histones have been implicated to act as repressors of gene expression. However, unlike the lactose operon and lamda phage repressors, histones apparently lack specificity for particular base sequence. Furthermore, there seem to be far fewer species of histones than genes with the result that there cannot be a one to one correspondence between genes or operons and specific histones. A number of mechanisms for de-repression by histones have been suggested. Among these are acetylation, methylation, phosphorylation and thiolation which, it is thought, might weaken DNA-histone binding. Recent work also suggests that chromosomal RNA may confer specificity on the histones.

Hormone Action

Work has also been directed very recently to understand turnover of histone components and their chemistry. It has been shown that the amino acid sequences of arginine-rich histone fraction IV, isolated from the chromatin of pea cell, is virtually identical with that from calf thymus nuclei. Since sequences of the histone fractions have been conserved with only two replacements throughout evolution, these moieties may be expected to have crucial function which is unprecedentedly insensitive to mutational changes.

Of central importance is the mechanism of hormone action in multicellular organisms. Attempts to explain the mode of action of hormones have been directed largely to seeking and finding explanations in terms of RNA involvement. I think that we are entering a most fruitful period in Biochemistry where we see that the structure of cells and their membranes exert a vital influence and control on most of the integrated greater understanding of hormone action should result from a consideration of the cell's enzymatic capabilities in relation to its structural organisation.

Information Transfer

Indeed, in the biochemical mechanisms of protein biosynthesis in cells of higher organisms, membrane function is a distinctive feature not encountered to the same extent in microorganisms. While the characteristics of enzyme-catalysed conversions of metabolites to products in aqueous systems occupied the mainstream of biochemical attention hitherto, the importance of cell structure in control of metabolic processes is now being increasingly recognised.

The protein synthetic capabilities of free and membrane-bound ribosomes of animal tissues have been studied by several workers. Many lines of evidence suggest that newly formed free ribosomes become attached to membranes of endoplasmic reticulum in order to begin their protein synthetic function.

An important aspect of protein biosynthesis in higher organisms is the mode of formation of ribosomes. Recent work suggests that ribosomal RNA is synthesised in the nucleolus, where it first appears as high molecular weight RNA. Messenger RNA is believed to be synthesised in extranucleolar region of the chromatin. Transport of these two RNAs from nucleus to cytoplasm presents special problems and is an area in which active work is underway.

Important Advances

For years, biochemical studies on the genesis of mitochondria have suffered from a certain lack of respectability, cytoplasmic inheritance being considered a sideline by most geneticists. In the last few years, a series of important advances in our knowledge of mitochondrial genesis have been made. It is now known that stable genetic determinants which influence the structure and enzymatic make-up of the mitochondrion can be transferred from one cell to another by purified mitochondrial preparations. It has been firmly established that DNA is an intrinsic and probably indispensable component of all mitochondria. Mitochondrial DNA from vertebrate tissues has been identified as having a unique circular structure. The presence of DNA in some other cytoplasmic organelles, such as chloroplasts and kinetoplasts, also seems to be established. In a number of animal tissues, presence of nuclear satellite DNA has been detected. The biological function of these intriguing satellite DNAs is as yet unknown.

We are entering a most fruitful period in Biochemistry where we see that the structure of cells and their membranes exert a vital influence and control on most of the integrated reaction sequences of the cell."

Future Trends

Other major problems where knowledge has lagged and where the application of standard techniques and approaches has met with resistance include: the mechanisms of selective permeability and active transport, the nature of assembly of respiratory enzymes, the manner of linking of respiration to phosphorylation, the manner by which cells efficiently synthesise many different types of individual proteins and enzymes and the manner by which cells reproduce their organelles and themselves, both under normal conditions and in the cancerous state. The answers to these unsolved questions will probably be found in detailed studies of membrane systems — a type of non-aqueous biochemistry or at least, biochemistry of reaction systems fixed on lipoprotein matrices.

"*The increasing knowledge that is being gained on the genetic code, its change in mutation and its transcription and translation as well as on the molecular architecture and mode of functioning of organisms will ultimately assist in accurately interpreting biological events that occured millions of years ago.*"

One major frontier of biological inquiry would still remain even after the origin of life and morphogenesis have been satisfactorily described in molecular terms. This is the higher nervous system. During the past decade, a number of lines of evidence have suggested that molecular events are involved in learning and in storage of information in the nervous system. These include the use of drugs to influence learning, memory storage and recall, the demonstration of changes in RNA and protein during learning experiences and the exciting reports of memory transfer through RNA. Intensive research is underway to explain memory processes in chemical terms. The unfathomable functions of the nervous system now appear to pose problems as hopelessly difficult as the phenomena of heredity did some decades ago. But there is no doubt that the bio-scientist will also conquer this territory and will have molecular explanations for such manifestations of life as consciousness and memory. An understanding of these processes could conceivably be the forerunner of man's attempts to control abnormalities of the higher nervous system.

Defining the 'Something'

Certainly, an abundance of problems in biology awaits solution, for we are far from understanding many critical biological phenomena. Yet, through advances in biochemical genetics and nucleic acid and protein chemistry, a comprehension of the most important properties of life, heretofore puzzling and mysterious appears within our reach. In the past, the utter lack of understanding of these properties of life had been a major factor leading to the view that living organisms possess an inherent, vitalistic 'something' perhaps akin to a 'spirit'. The ability to define this 'something' in physical and chemical terms may indeed be said to have been attained in a large measure. The expression and transmission of heritable traits and the broad outlines of DNA replication and gene action are

(Continued on page 8)

Powerful Linear Accelerator at Saclay

THE Nuclear Research Centre at Saclay has an electron linear accelerator that develops a power of 600MW. It is an extremely high performance apparatus capable of carrying out important experiments and observations for modern physics.

The apparatus was built by the Compagnie Generale de T.S.F. (C.S.F). It is buried in a blockhouse at a depth of over 7 m and is covered with a mound of earth over 9 m thick. It is enclosed inside concrete walls over 4 m thick so that its operating crew will be well protected against the intense radiations it gives off.

The principle is that of a sort of gun inside of which a high-frequency electric wave is propagated in such a way as to push electrons along. Its purpose is to produce a beam of high intensity. The beam produced at Saclay is made up of several billion electrons made to undergo impulses at the rate of 1,000 ten-microsecond impulses per second.

The heart of the accelerator is 0.71 inches in diameter (18 mm), consisting of a high vacuum surrounded by several envelopes. Here and there are located vacuum pumps and magnetic lenses for guiding the beam. At the beginning of the beam, the electrons attain about the speed of light. Then they take on mass, and the accelerator becomes a sort of "weighting device".

At the end of the apparatus, the beam is divided in two by powerful electromagnets and each of the new beams is then sent to one of the places where experiments are made. In this way several investigations can be carried out at the same time. ●

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March 1, 1970

(Sd.) JAGANNATH SHARMA

(Continued from page 7)

helping greatly to bring this property to precise definition. Another property is the control of cellular structures; recent experiments on structure-functions of sub-cellular organelles, on active transport and on cell membranes, indicate that understanding of this property is well within our grasp in the not too distant future.

In passing, I may mention how we have tended to neglect the mainstream of evolution in favour of detailed studies on mechanisms of specialisation and speciation. We know little about what has contributed to the continuity of life. We may, however, confidently expect that the increasing knowledge we are gaining on the genetic code, its change in mutation and its transcription and translation, as well as on the molecular architecture and mode of functioning of organisms, will ultimately assist in accurately interpreting biological events that occurred millions of years ago.

High Expectations

I would like to conclude with a practical note. Many of the conveniences of modern life became possible because of the earlier advances in physics and chemistry, especially organic chemistry. In the same way, we may hope to see, in the next decades, increasing applications of molecular biology to outstanding problems of human welfare. We are already achieving significant benefits in tailoring micro-organisms and crop plants through genetic engineering or controlled mutation breeding. Similar development of techniques by which genes in human sperm cells could be engineered to obtain selected physical and mental abilities are admittedly a long way off. Nevertheless, there are high expectations of success in the medical field, such as with the diseases of auto-immunity, inherited disorders of metabolism, the treatment of viral infections and the nature and the cure of cancer. *(Excerpted from a talk given at a Symposium on "Macromolecules in Storage and Transfer of Biological Information" at Trombay, December 1969).*

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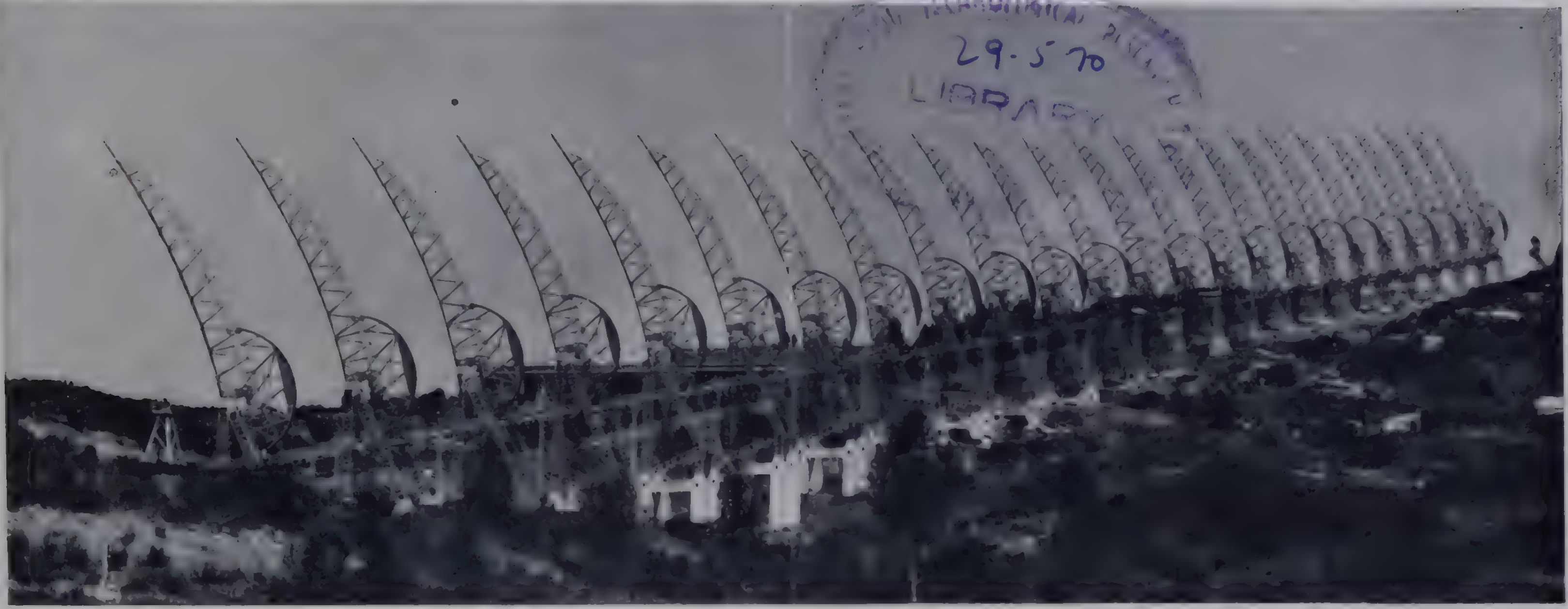


A view of the 530 m. long Ooty Radio Telescope which is located at an altitude of 2,200 metres in the Nilgiris. Each of the 24 frames is 30 m. wide. The instrument, shown pointing towards the western horizon, can be rotated in unison by 140°.

A Radio Telescope at Ootacamund

ON a hill slope close to Muthorai, a village just outside Ootacamund in the Nilgiri Hills, one of the world's largest radio telescopes is in operation.

Designed and fabricated wholly in India under the direction of Prof. G. Swarup of the Tata Institute of Fundamental Research, Bombay, the 530 m. long, 30 m. wide instrument has a novel design which takes full advantage of the location of India close to the geographic equator. A number of leading Indian engineering firms, the Mazagon Dock, the Bhabha Atomic Research Centre and the Tata Institute were associated with its fabrication and installation. There was no foreign collaboration of any kind in this project.

Three Sites

The telescope is located at an altitude of about 2,200 metres. Unlike an optical telescope, a radio telescope need not be located in the mountains at a high altitude. After an intensive search of South India, only three suitable sites with a slope equal to the latitude in the north-south direction over a length of half-kilometre could be located — and these were all in the Nilgiris. The site was finally selected in December 1965 and became available for project work in April 1966.

The whole project was executed under the auspices of the Department of Atomic Energy. Funds were made available by the Department to cover all costs on the instrument, including civil works at the site. The National Science Foundation of the United States made a generous grant of $70,000 (approx. Rs. 5.25 lakhs) to the project which was utilized for procuring a fast on-line computer which considerably enhances the sophistication of the system for programme work and analysis.

See page 4

The know-how developed as a result of work on this radio telescope falls into two categories : that relating to large antenna systems and that relating to electronics of receiver systems. Already, through this, contributions have been made to the development of microwave antenna systems needed in India.

Major Facility

The main programme that will be conducted with the instrument are : studies of radio galaxies — particularly the very distant and weak ones by the method of lunar occultation; studies of interplanetary scintillation; studies of quasars and of the recently discovered pulsating radio sources called pulsars; studies of radio emission from planets (particularly Jupiter), flare stars and the sun.

The telescope is a major national facility for research in radio astronomy — one of the frontier fields of science today. ●

New aid to astronomical research promises exciting discoveries

'Galaxy' – The High-Speed Star Gazer

As man thrusts deeper into space, astronomers, concerned not with the closer planets but with bodies that are thousands of light-years distant, are finding the answers to mysteries which in the past have been, quite literally, obscured.

The universe is built of galaxies, and galaxies are built largely of stars. An understanding of star formation is therefore necessary if we are to learn how the galaxies and the universe have evolved; and at the Royal Observatory, Edinburgh, use is now being made of a machine — the first of its kind in the world — which will provide hitherto unyielded information arising out of the search for newly-formed stars.

The machine, called the Galaxy (General Automatic Luminosity and X Y machine) was conceived and designed at the observatory and is manufactured by Faul-Coradi (Scotland) Ltd.

The invention of the Schmidt telescope more than 30 years ago provided astronomers with the means of recording information about the stars at an unprecedented rate.

Interstellar Dust

A single photograph of an area of the sky a few times larger than the area covered by the moon, taken in a few minutes on a clear, dark night by a Schmidt telescope of even moderate size, records images of tens of thousands of stars. Such photographs contain a wealth of information. Precise measurements of the positions of star images on photographs taken at different times give the angular motions of the stars, enabling their distances to be calculated. The distribution and motions of the stars which make up our galaxy can be obtained in this way.

Measurements of the strengths of the images give the brightness of the stars, and by taking photographs through different colour filters the temperatures of the stars can be deduced. Similar measurements enable the distribution of interstellar dust — the galactic fog — to be determined. This dust increasingly appears to play a crucial role in the formation of stars and the evolution of galaxies.

The task of extracting all the information from the photographs, of measuring precisely the positions and image strengths of tens of thousands of stars on each, has hitherto been beyond the capacity of available measuring devices. Because only a few hundred selected stars on each photograph could be examined, this severely restricted the research programmes of astronomers. For example, the search for newly formed stars, which are heavily obscured by clouds of interstellar dust surrounding them, has been limited to a few very small parts of our galaxy of stars.

By Prof. Hermann Bruck

Astronomer Royal for Scotland

The new Galaxy machine enables astronomers to overcome these limitations, and make full use of the information they can record at the telescope. It is now being used to measure photographs taken as part of one of the observatory's various programmes — the search for newly-formed stars almost hidden by dense obscuring clouds of interstellar dust.

Automatic measurement

In close co-operation with the Royal Observatory, Edinburgh, the design and construction of the Galaxy was embarked upon in July 1963 when a contract was placed with the Scientific Instrument Control Division of Ferranti Ltd. at Edinburgh. The requirements laid down that the precision of measurement should be one micron in the position of a star image and a quarter of a micron in the size, and that the machine should find and measure a thousand star images an hour, entirely automatically.

Four main features of the machine were decided upon: a cathode ray tube to scan the photograph with a spot of light to find the star images and measure their sizes and densities; a precise mechanical carriage to hold and position the plate with an accuracy better than a micron; a system (developed by Ferranti) for measuring the carriage position to a micron; and an electronic system similar to a computer to control the operations.

Intensive Trials

The various parts of the system were connected up and tested together for the first time in March 1969. The machine was put through a series of increasingly demanding tests, and by the end of June it had become apparent that its performance was exceeding expectations. Positions were being measured with a precision of half a micron, better by a factor of two than that demanded by the specification, and image sizes were measured with a precision 20 per cent. better than specified.

Intensive trials of the machine in the following three months showed that this performance was maintained, and the machine was formally accepted in October. By October 30, colours and brightnesses of about 40,000 stars had been measured.

To find the star images on a photograph, it is scanned by a small spot of light produced by a cathode ray tube and projected down to a chosen size, 16 microns across being typical. The light passes through the photograph and is measured by a photoelectric cell.

The passage of the spot of light over a star image is then detected by the cell as a reduction in brightness, and the position at which the event occurred is recorded. With this resolution of 16 microns, the plates currently being measured are searched at a rate of 30 square millimetres per minute

(Continued on page 8)

Prof. Menon Is Seventeenth Indian FRS

PROF. M. G. K. Menon, Director of the Tata Institute of Fundamental Research, Bombay, is the seventeenth Indian to be elected Fellow of the Royal Society of London. Founded in 1660, the Royal Society occupies a unique place in the scientific world and election to it is considered a high honour by scientists.

Other Indians elected to the Society are : A. Cursetji, S. Ramanujam, H. J. Bhabha, P. Maheswari, S. S. Bhatnagar, K. S. Krishnan, D. N. Wadia, M. N. Saha, S. K. Mitra, B. Sahni, C. V. Raman, S. N. Bose, P. C. Mahalanobis, C. R. Rao, T. R. Sheshadri and S. Chandrasekhar.

Prof. Menon, 42, worked with Prof. C. F. Powell, FRS at the University of Bristol, England, during the years 1949-1955. Powell was the scientist primarily responsible for developing the nuclear emulsion technique into a powerful tool capable of great precision for study of cosmic ray, elementary particle and nuclear phenomena. For these contributions, and the discovery (through observations on tracks in photographic emulsion) of the pi-meson and its decay into the mu-meson, Powell was awarded the Nobel Prize for Physics in 1950.

Neutrino Experiment

In work carried out with his colleagues at Bristol (notably Prof. C. O'Ceallaigh, M. W. Friedlander and D. Keefe), Prof. Menon contributed to development in the nuclear emulsion technique, particularly the use of stacks of stripped emulsions as large as 15 litres in volume and methods of mass determination; and through these technical developments there emerged significant results relating to the decay modes and interactions of the heavy mesons and hyperons.

Results of particular importance included the demonstration that among the charged secondary particles arising in the decays of heavy mesons there were pi-mesons, mu-mesons and electrons some arising through two-body, and others through three-body decays; that slow negative heavy mesons were much less abundant than their positive counterparts; and the first observations on the nuclear scattering of heavy mesons and its interpretations in terms of the "strangeness" concept that has just been introduced theoretically.

Prof. Menon was one of the principal spokemen of the Bristol group in those years when it was the most important research centre for work in these fields.

During 1952-1953, Professor Menon was Research Associate at the University of Bristol and, from 1953 to 1955, held the Senior Award of the Royal Commission for the Exhibition of 1851. The only other Indian to hold this Award earlier was the late Homi Bhabha.

Cosmic Ray Studies

Since 1955, he has been working at the Tata Institute of Fundamental Research in Bombay. He first concentrated, (along with V. K. Balasubramanyan, G. S. Gokhale and R. T. Redkar), in developing the technology of fabricating and flying very large balloons under tropical conditions through the very low temperatures of the equatorial tropopause. This is now a facility that enables cosmic ray work at high altitudes close to the geo-magnetic equator to be carried out in India. The significant work of the TIFR cosmic ray group on the high energy electron component, and on high energy X-ray sources are illustrative of the importance of this facility. Professor Menon's interests over the past decade have been cosmic ray studies deep underground in the Kolar Gold Fields in South India; these relate to phenomena involving high energy muons and neutrinos; this work has been carried out in collaboration with Professor S. Miyake and his group at the Osaka City University, Japan, and with Drs. V. S. Narasimham, P. V. Ramana Murthy and B. V. Sreekantan of TIFR.

Nuclear Emulsion Technique

The neutrino experiment at a depth of two and a half km. below the earth's surface involved the group under Professor A. W. Wolfendale of the Durham University, U.K. In this experiment, the first unambiguous observation was made of the interaction of a natural neutrino. These experiments illustrate the possibility of working on topics at the fore-front of scientific interest by utilizing fully the advantages that may otherwise exist — in this case the existence of very deep gold mines.

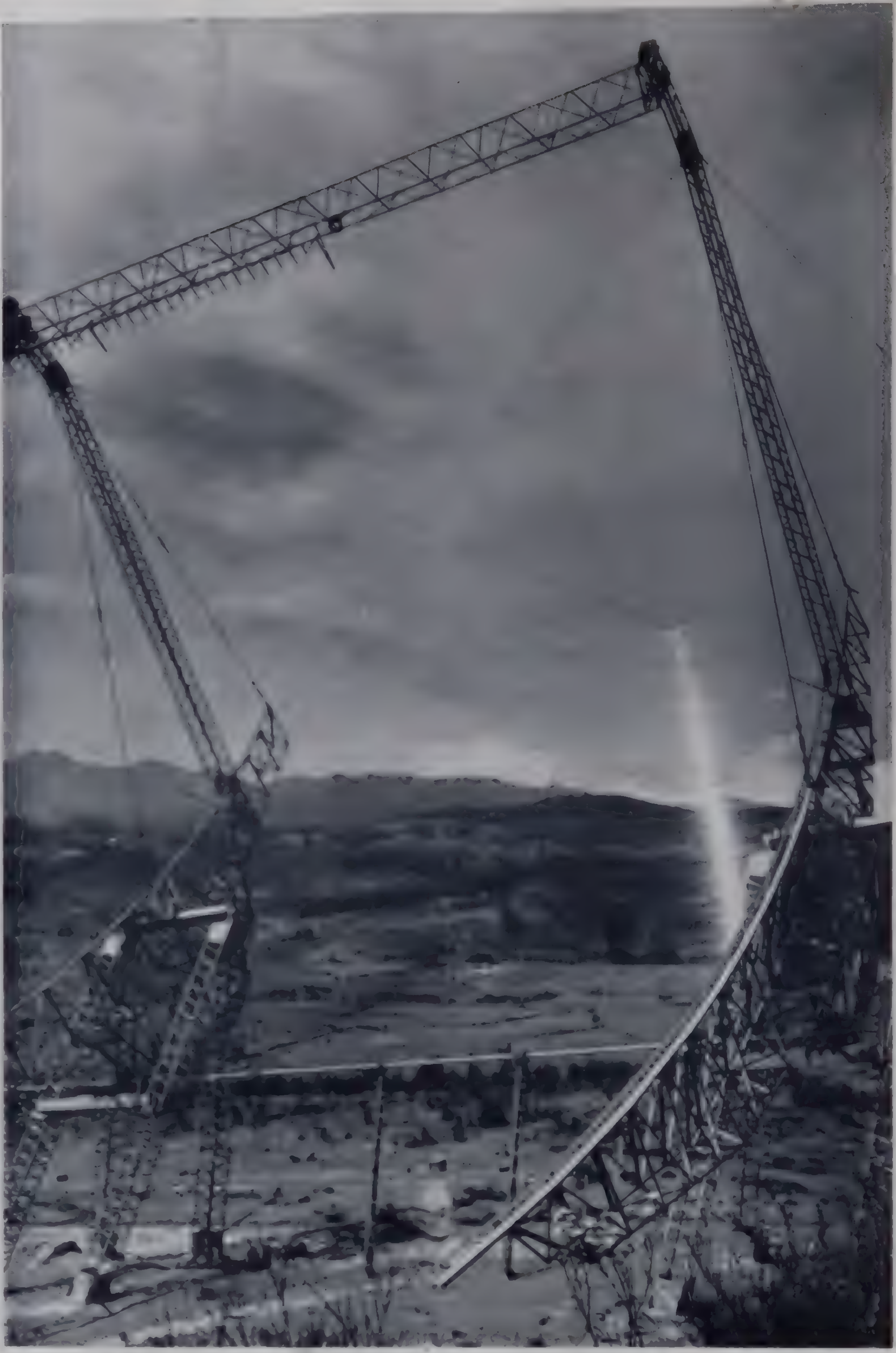
Professor Menon has also concentrated over the past decade in his capacity as Dean, Physics Faculty, Deputy Director (Physics) and as Director in the growth of programmes and groups over a wide spectrum of scientific endeavour at TIFR, which today has many outstanding scientists who have carried out work that is internationally recognized. ●

The Ooty Radio Telescope — A Major Facility

by Prof. Govind Swarup
Tata Institute of Fundamental Research

THE space age dawned with the launching of the first earth satellite in 1957. Since then, there have been a series of spectacular events, crowned by Man's landing on the moon last year. Over the same period, there have been, through studies in astronomy and astrophysics, advances concerning our knowledge of outer space that should be truly ranked as spectacular from the viewpoint of science, though by their very nature they have captured less public attention. These advances have been concerned not only with space in the immediate vicinity of the earth, but with space and the phenomena occuring in it up to the most distant reaches in the Universe that man has been able to penetrate.

Phenomena that occur in space give rise to radiations of various types; the most familiar radiations that we receive on earth are light and heat from the sun—and this arises through burn-up of the nuclei of light elements through nuclear fusion processes in the sun's interior as a result of which great quantities of energy are released. The radiations from space cover a wide range of wavelengths from the very long wavelengths characteristic of radio waves, to the very short wavelengths characteristic of the most energetic cosmic rays and gamma rays. By studying these radiations, scientists have been able to discover the nature of the phenomena that occur in space, including those that took place in the distant past.



Curved light streak shows reflection of sunlight from the fine stainless steel wires forming the reflecting surface.

New Window

Through the ages man has looked out at the Universe around him and studied it with his eyes, and with the help of instruments such as sextants and optical telescopes. In 1931, Carl Jansky discovered that there were also radiations in the radio region from outer space that he could identify as coming from specific regions such as the Milky Way. With this discovery was opened a wide new window into the Universe — that of Radio Astronomy.

A radio astronomer studies the Universe using radio waves, instead of the light waves used by the optical atronomer. Radio waves, like light waves, are electromagnetic in nature. Light from stars and galaxies generally originates from hot gases at temperatures of about 6000 to 20000°K. But radio waves arise differently. They are emitted by highly energetic particles as they move with velocities close to that of light in the presence of magnetic fields. These natural radio waves produce a hissing type of noise when received by a radio telescope. With the help of a directional antenna, or a radio telescope, the strength and direction of radio waves received from different parts of the sky can be determined and a map of the radio sky prepared. It should be pointed out that just as there are stars which are visible, there are discrete radio sources or radio galaxies that can be 'seen' through radio waves with radio telescopes.

Studies of distant radio galaxies and quasi-stellar objects (quasars) have provided evidence of vast explosions occurring in distant parts of our Universe which give rise to highly energetic particles. It appears that powerful explosions occur in some galaxies as a result of which matter more than a million times the mass of the sun is completely converted to energy. The energy released is truly fantastic. Many theories have been propounded, but the mechanism of these violent events is little understood.

Powerful Facility

Radio Astronomy has yielded spectacular results over the past four decades of its existence. The past decade especially has seen some of the most exciting discoveries ever made through this window. These discoveries relate to quasars and pulsars, the existence of a universal microwave backround radiation, the opening up of maser astronomy with studies of the hydroxyl (OH) molecules, and evidence of the existence of molecules as complex as ammonia, water and formaldehyde in the outer reaches of space.

In India, radio astronomers have been provided a new tool for studies in this frontier field of science. At Ootacamund in the Nilgiri Hills, one of the most powerful radio telescopes in the world was commissioned in February this year. Designed and built wholly by Indian scientists and engineers under the aegis of the Tata Bombay, this advanced instrument provides Indian scientists opportunities of working at the very limits of man's endeavour in this area anywhere in the world today.

The Ooty radio telescope has a special design which utilizes the location of India near the geographic equator; this design provides for large gathering power and also sufficient steerability at a relatively low cost. The instrument has a reflecting surface which is 530 m long and 30 m wide. It is about 4 times more sensitive than the 250 ft. (approx 76.2 m) dish at Jodrell Bank, England; but it is not a general purpose instrument like the latter as it operates in a fixed radio band of 324-329 mega-hertz only. A radio telescope primarily consists of a large surface on which the radio signals coming in from outer space can be reflected and brought to a focus at a point or along a line; from the focus, the signals are carried to a receiver system where they can be recorded and analysed. The most familiar design of a radio telescope is the deep saucer-like dish, such as the dish at Jodrell Bank in England; such a dish is fully steerable and can be pointed in any appropriate direction; it can be rotated along two axes that are at right angles, and can thus follow a star or galaxy during its daily motion across the sky.

The Ooty radio telescope uses a novel design. Its surface is in the form of a parabolic cylinder — like that of a long trough with a parabolic cross-section. Such reflectors provide large sensitivity or collecting area at a relatively low cost; they have been built elsewhere in the world, but they are not steerable in the east-west direction and so they cannot be used for tracking or following radio sources for more than few seconds of time. Utilizing India's proximity to the geographic equator, we have installed a 530 m long trough type reflector with its axis in the geographic north-south direction on a slope of 11°24', this angle of inclination being equal to the latitude of the station. Thus the axis of the instrument is kept parallel to the earth's axis of rotation; this arrangement enables us to follow radio sources in the east-west direction for $9\frac{1}{2}$ hours per day by a mechanical rotation of the reflector along its long axis. The beam of the radio telescope, or the direction in which it is looking, can be moved in the north-south direction by changing the lengths of interconnecting transmission lines. Thus, by mechanical rotation in the east-west direction, and by electrical phasing to obtain beam movement in the north-south direction, the telescope achieves steerability. *(See figure on page 6.)*

Prof. Govind Swarup, 41, has been with the Tata Institute of Fundamental Research since 1963. An MSc in Physics from Allahabad, Professor Swarup worked during 1950-53 and 1955-56 at the National Physical Laboratory, New Delhi. Between 1953-55 he was with the Radio Astronomy Group of the Commonwealth Scientific and Industrial Research Organisation, Sydney, Australia, working with Dr. J. L. Pawsey. Between 1956-63 Prof. Swarup worked at the Harvard University (for one year) and for six years at Stanford University where he obtained his Ph.D. in Radio Astronomy in 1961.

Parallel Wires

The telescope is located on a hill that has a slope of about 11°. On this slope there are 24 equidistant, tall steel towers; and on top of each of these is mounted a parabolic frame; the two ends of each parabolic frame are 30 m. apart. The 24 frames span

(Continued on page 6)

(Continued from page 5)

a horizontal distance of 530 m. These frames are connected together by 1100 stainless steel wires, each 530 m. long. The wires are parallel to one another and constitute the radio reflecting surface of the telescope. Radio waves incident on the surface are reflected on the 968 radio dipoles placed along the focal line of the telescope and thence carried to a multi-beam receiver providing 12 simultaneous beams in the sky. The entire 530 m x 30 m surface can be rotated in unison through an angle of about 140° using complex electrical and mechanical fixtures — all designed and fabricated in India.

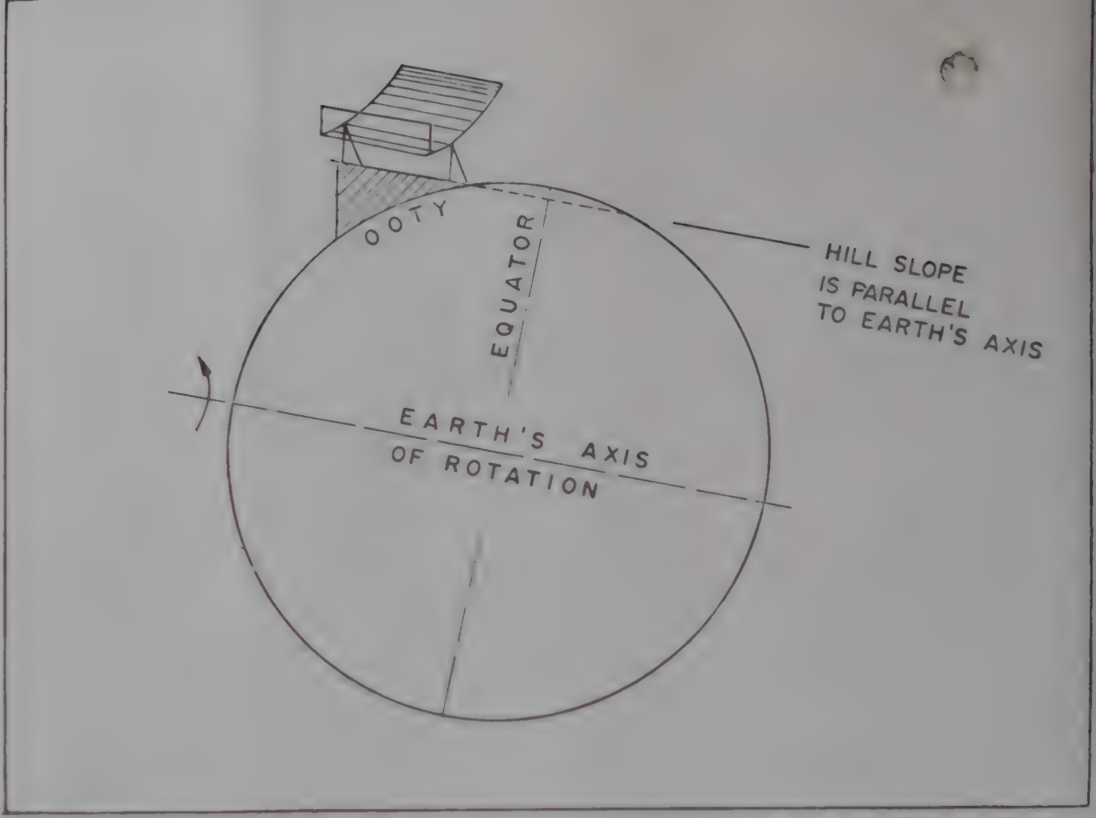
"Lunar Occultation"

The cost of a parabolic dish with the same sensitivity and steerability as the Ooty Radio Telescope is estimated to be at least 20 times higher. An array consisting of a large number of smaller size dishes would also cost very much more. But in contrast to a parabolic dish, the parabolic cylindrical reflector of the Ooty Telescope can be operated at only one or two fixed radio bands.

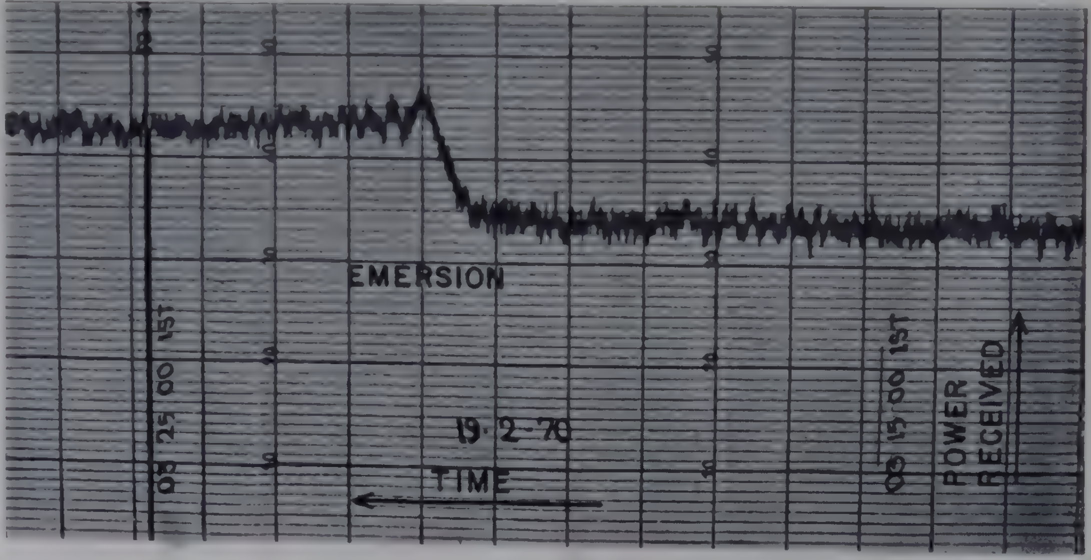
The design of the Ootacamund Radio Telescope was conceived to enable study of distant radio galaxies by the method of "lunar occultation". As the moon moves in the sky, its sharp edge eclipses radio waves from a distant radio source. A narrow source goes behind the moon's limb suddenly but a broad source disappears gradually. As the moon moves away, the source emerges again. A record of this phenomena allows a very precise pin-pointing of a radio source and also provides information about the shape of the radio source. This technique is extremely powerful and gives resolution of better than a second of arc; it has not been exploited fully so far because of the lack of a sufficiently large and steerable radio telescope in any part of the world.

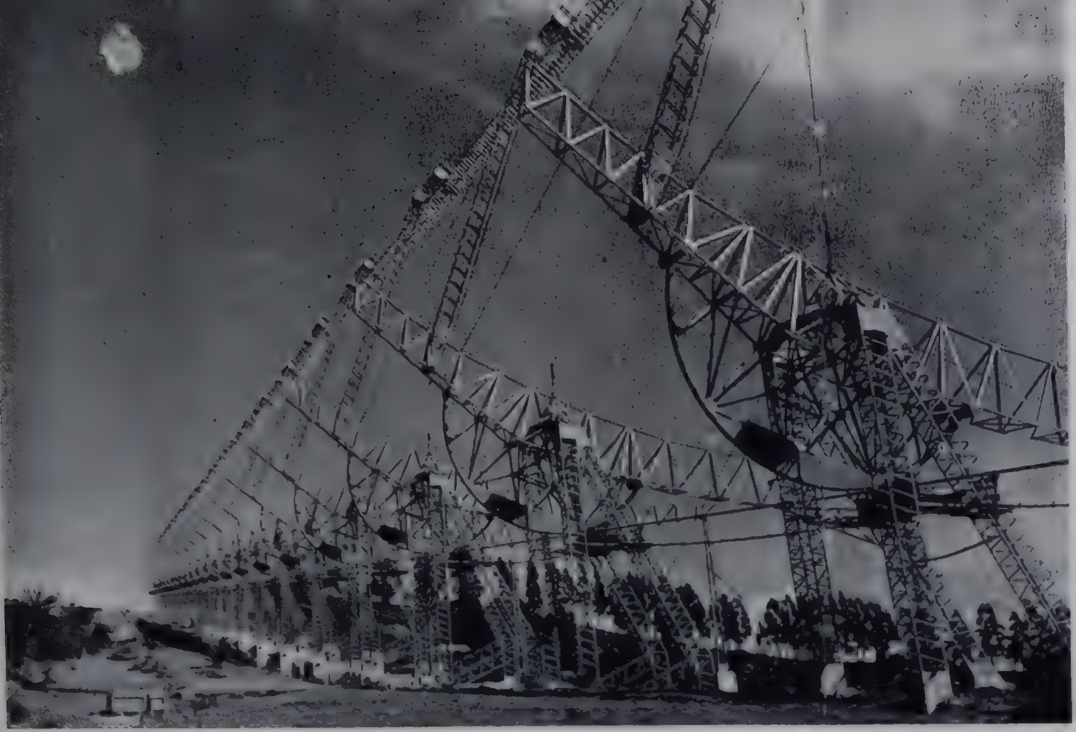
New Sources

At Ooty, during the first 14 days of operation, occultation observations of 16 radio sources were made; 11 of them were objects which were catalogued by other observatories, but for which detailed structure data was not available; 5 of them have been detected by us for the first time. So far astronomers have catalogued more than 15,000 sources, but detailed structure with resolution of few seconds of arc is available for only about 30 comparatively strong sources. With the Ooty instrument we expect to observe several hundred new sources every year with resolution of about 1 second of arc. These observations will be compared with photographs taken with the 48" (approx. 1.2 m.) telescope of Mt. Palomar Observatory to find the nature of associated optical emission. It is also planned to study the same objects with the new 48" (approx. 1.2 m.) telescope at Rangapur of Osmania University, near Hyderabad and with the 40" (approx. 1 m.) telescopes being installed at the Kodaikanal and Nainital Observatories. The data will be used for studying the origin and evolution of radio galaxies. Studies of very distant and consequently weak radio galaxies lying at the edge of the



A record of lunar occultation observations of radio source 4C 22·21. Power received by the radio telescope increases as source emerges from behind the moon's limb. The rate of increase (diffraction pattern) gives information about source structure.





A close-up of the radio telescope. Radio waves reflected by a surface consisting of 1100 stainless steel wires are focussed to a long line shown at the upper end of the picture. Half circle on each tower is a 5 m dia. gear meshed to a 530 m long drive shaft.

universe is likely to be highly significant for cosmological problems relating to the nature of the universe.

It is also planned to undertake a survey of weak radio sources in the southern hemisphere and to measure the declination of some of the already catalogued radio sources by other observatories. The instrument will also be available for studies of galactic objects, studies of radio emission from planets (particularly Jupiter), flare stars and the sun. We may in addition undertake measurements of deuterium to hydrogen ratio because of the considerable astrophysical significance of the problem.

A major programme has been started for detailed studies of the recently discovered pulsating radio sources (pulsars). These sources emit pulses of radio emission with a period accurate to one part in a million. So far only 50 pulsars have been detected by radio astronomers with periods ranging from a fraction of a second to a few seconds. It is believed that pulsars are associated with highly compact neutron stars which have densities of about billion times that of the earth and which rotate roughly once a second. Our instrument at Ooty is well suited to study them in detail and perhaps also for discovering many new pulsars.

Other Telescopes

The radio telescope is being currently operated in the frequency band of 324—329 MHz. It is planned to build another dipole array and a receiver system for extending the operation of the instrument to a second frequency, around 100 MHz. A radio interferometer is being set up by locating two 13.5 m. dishes at the ends of a north-south line, 3.5 km to the west, and parallel to the axis of the radio telescope.

It would be of interest to compare the Ooty instrument with other radio telescopes in the world. The 250-ft. (approx. 76.2 m.) dish at Jodrell Bank, England, or the 210-ft. (approx. 64 m.) dish at Parkes, Australia are very valuable instruments as they focus radio waves to a point and therefore can be operated over a wide frequency range, from centimeter to meter wavelengths. But their resolution is very limited as their size is only a few hundred times to the wavelength of radio waves.

radio telescopes of special design have been constructed in several countries —for example, the one mile long (approx. 1.6 km) aperture-synthesis interferometer developed by Prof. Ryle in England or the one mile (approx. 1.6 km) crossed-antenna built by Prof. Mill in Australia. But to get resolution of about one second of arc that is achievable with moon-occultation, one would need phase-stable interferometers having a size of about 20 km. Such interferometers have not been built so far.

Jodrell Bank

The sensitivity of the Jodrell Bank dish is lower by a factor of four than that of the Ooty Radio Telescope. Therefore, the Jodrell Bank dish is not suitable for study of a large number of radio galaxies by the method of lunar occultation. The only steerable radio telescope in the world with larger sensitivity than that of the Ooty Radio Telescope is the 1000-ft (approx. 300 m) bowl in the ground at Puerto Rico, U.S.A. But it can follow the moon for only about 10 per cent of time compared to the Ooty instrument.

The Ooty radio telescope represents a major facility in a frontier area of science. It can make a significant contribution to the training of young scientists in the country, who will either be able to use it for advancing fundamental knowledge in the areas of astrophysics and astronomy, or through their training, contribute to the country's needs involving large antenna systems and associated electronics.

The late Dr. Bhabha had always envisaged that major national facilities set up in the country would be made available to institutions and workers who could make use of such facilities, but who by themselves could not set these up or utilize them fully. It is hoped that the Ooty Radio Telescope will make its contribution to the growth of astronomy and astrophysics in India. ●

(Continued from page 2)

10,000 stars being found and recorded per hour.

A Closer Look

When the star images have been found, the carriage carrying the photographic plate is moved to put each star in turn beneath a scanning system working at high magnification, for a more detailed examination of each image.

The spot of light is now only one micron across, and this is scanned in a spiral pattern over the image. The amount of light passing through and around the image is again measured by a photoelectric cell. If the image is not centred on the spiral pattern, more light passes through one side than through the other, and the carriage is moved until equality is obtained. The position of the carriage is measured, and in this way the position of the image is determined in units of a micron.

Meanwhile, the measurements of the amounts of light passing through different parts of the image are being examined by the control system in order to determine the image structure. A measurement of the strength of the image is obtained in units of a quarter of a micron; this measurement is directly related to the brightness of the star photographed. The measurements of position and brightness are coded as output on computer tape, at the rate of 1,000 stars an hour, for subsequent analysis in the observatory's computer.

The most significant feature of the Galaxy machine is not so much its precision as its speed. The number of stars which can be photographed by even the moderately-sized Schmidt telescopes at the Royal Observatory, Edinburgh, is some tens of millions, and in the past when we have wanted to measure position or brightness we have been confined to a few hundreds or thousands of stars.

We had information, therefore, about only a very tiny sample of the stars in our galaxy, which contains some two hundred thousand million stars. Now, with the Galaxy machine, it is possible to measure substantial samples of the total number of stars which are detectable.

The importance of all this to astronomers is that it makes possible researches that could not be undertaken before because we were unable to collect the information required to carry them out. For instance a search of the whole Milky Way for newly-formed stars was a task beyond the capacity of existing instruments.

Essential Equipment

Over the next few years there will be an increase in the number of large telescopes available to British astronomers, and this will in turn increase the need for machines like the Galaxy. Indeed, any observatory in any part of the world which is involved in the work of measuring the position and brightness of stars will find it essential to be equipped with such a machine if it is going to be able to compete in the field of modern astronomical research.

We in Edinburgh now face a major task in programming the computer to deal with the output of the Galaxy machine, and we look forward with some excitement to the discoveries which will be made by using it to explore the galaxy of stars. *(Reprinted from "This Is Britain" March 1970)*

The Harwell Isotope Bureau–A

ON May 1st a new body — the Harwell Isotope Bureau — will come into existence at the Atomic Energy Research Establishment, U.K. strengthening and extending a 20-year old link with industry.

From its very beginnings Harwell has worked to develop and promote useful industrial applications for the radioisotopes produced in its nuclear reactors, but since 1960 all work in this field has been carried out at the Wantage Research Laboratory, some 16 km away. Now, as part of the process of concentrating the resources of the UKAEA, the Wantage Laboratory is being closed and its work and staff are being transferred in stages to appropriate Harwell divisions.

The Isotope Bureau is being created to ensure that there is no break in the close contacts that Wa[illegible]age staff have established with industrial organisations over the last 10 years, to extend these contacts further, and to link them with the full resources of the parent establishment.

The Isotope Bureau will take over the functions of the Industrial Liaison Office at Wantage, and will act as a central point for handling incoming enquiries relating to isotope applications and radiation processing. It will actively seek to promote industrial interest in radioisotope instruments and tracer techniques and in the uses of ionizing radiations, and it will seek new ways in which Harwell's special skills and equipment can be used to the best advantage of industry and of the nation. ●

Symposium on Radiation Physics

A national symposium on Radiation Physics will be held at Trombay from November 9 to 12, 1970, under the auspices of the Bhabha Atomic Research Centre (BARC) Bombay 85. The topics to be covered are : interaction of radiation with matter; radiation transport; radiation dosimetry; environmental radioactivity; and units and standards.

Scientists wishing to participate are requested to contact Shri K. Santhanam, Secretary, National Symposium on Radiation Physics, Health Physics Division, BARC, Bombay 85.

The last date for submission of papers and abstracts is September 1.

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Report on 1969-70

Indian Nuclear Effort Is 25 Years Old

THE atomic energy effort in India is in its 25th year, having begun with the establishment of the Tata Institute of Fundamental Research in Bombay in June 1945. The quarter century marks the commencement of the era of nuclear power in the country: the 380 MWe Tarapur Atomic Power Station, the first nuclear power station in India and the largest operating nuclear power plant in Asia today, was dedicated to the Nation by the Prime Minister on January 19, 1970. The Station commenced trial generation of power from April 1, 1969 but became fully operational on Gandhi Jayanti Day, October 1969. From April 1, 1969 till March 31, 1970 it had generated over 1,300 million units of power for the two States of Gujarat and Maharashtra which share its output.

Atomic Power

Two other atomic power stations are now under construction: The 400 MWe Canada-aided station at Rana Pratap Sagar in Rajasthan, and the Kalpakkam Atomic Power Station in Tamil Nadu. The first unit of the Rajasthan Station is expected to be completed in 1971 while the second would be ready in 1974. The Kalpakkam station will mark another milestone in India's technological development as it will be wholly built without foreign collaboration, and with almost 80 per cent indigenous content.

At the Bhabha Atomic Research Centre, the hub of nuclear research work in India, activities have increased and diversified to meet the demands of the expanding nuclear programme.

FABRICATION OF NUCLEAR EQUIPMENT AT TROMBAY. Here is a gigantic access door fabricated at the Central Workshops of BARC for reactor no. 1 of the Rajasthan Atomic Power Project. It is undergoing final check up before despatch. Two such doors have already been delivered, including the one above (See page 4).

Among the important activities of the Centre is the preparation of radioisotopes and labelled compounds, which it also exports. During the year, the value of radioisotopes, equipment and services sold by its Isotope Division totalled Rs. 28.21 lakhs, including Rs. 3.87 lakhs in exports. In all, 24 countries including France, Sweden, Hungary, Denmark and Austria bought Trombay-produc-

(Continued on page 2)

BARC Developed Know-

(Continued from page 1)

ed isotope products and equipment in this period. Among the equipment, mention may be made of the export of two irradiation units — Gamma Chamber 900 — containing powerful sources of cobalt 60, to Burma and Kenya for use in agricultural and industrial research.

Mention may also be made of a tehnique developed for inspection of Boeing 707 jet engines. Using an indigenously developed remote-controlled radiography camera it has been possible to detect bow in the vanes of Air-India Boeings. This investigation has been done in India for the first time.

Plant Breeding Programmes

The Biology Division of the Centre is engaged in plant breeding programmes, among other investigations. It has evolved six groundnut mutants which are being tested at several centres through the All India Oilseeds Research Project. And, in collaboration with the Central Rice Research Institute, it has isolated short, dwarf and early flowering mutants of rice. Four slender grain mutants, TR-6 to TR-9 have been included in the Slender Grain Varietal Trials conducted by the All India Coordinated Rice Improvement Project.

Research programmes on basic and applied aspects of cellular metabolism and the development of food irradiation procedures is being conducted by the Biochemistry and Food Technology Division of the Centre. During the year, it continued experimental programmes on the development of promising radiation preservation procedures for perishable foods. Large scale feasibility trials on disinfestation of wheat, extention of storage life of onions and preservation of fish and fish products are in progress at its Food Irradiation and Processing Laboratory.

Development work on medical uses of radioisotopes — for diagnosis, treatment and for understanding desease processes — is being done at the Radiation Medicine Centre of BARC. An essential part of the activity of the Radiation Centre relates to training of medical doctors and technicians in the use of radioisotopes in their practice.

Electronics

The Electronics Division is engaged in intensive development work on nuclear and non-nuclear electronic instrumentation and equipment. It is also assisting the Electronics Corporation of India Ltd. (ECIL) at Hyderabad, a Government of India concern, through transfer of know-how. Thus items such as the on-line computer TDC-12, 400 channel analyser, medical spectrometer and processes relating to semi-conductor devices, developed by the Electronics Division of BARC are being taken up for production by the Corporation.

The Chemical Engineering Division is producing nuclear grade uranium metal for the CIRUS research reactor, and ceramic grade uranium oxide required for the first half charge for the Rajasthan Atomic Power Project reactors, at its Uranium Metal Plant at Trombay. It is contributing to the setting up of a heavy water upgrading unit at the Rajasthan Atomic Project and also assisting the Indian Rare Earths Ltd. for producing thorium nitrate by the solvent extraction process. In addition, the Division is engaged in training personnel for the Nuclear Fuel Complex that is being built at Hyderabad. The Division is also involved in the Space Programme: it was responsible for setting up the Rocket Propellant Plant at Thumba for manufacturing solid propellants for Centaure rockets.

Atomic Fuel

Meanwhile, the Fuel Reprocessing Division of the Centre is working on the design of the Power Reactor Fuel Reprocessing Plant at Tarapur. The construction of the plant building is about 40 percent complete and work on associated electrical installations is progressing.

The Atomic Fuels Division is engaged in developing and fabricating fuel elements and components for research and power reactors.

It is fabricating half the initial fuel charge for unit 1 of the Rajasthan Atomic Power Station. On the basis of technical reports prepared by the Division, a Ceramic Fuel Fabrication Plant, an Enriched Uranium Oxide Fuel Fabrication Plant and a Zircaloy Fabrication Plant are being set up at Hyderabad as part of the Nuclear Fuel Complex.

The Health Physics Division of the Centre carried out detailed analysis of fallout debris from the tenth Chinese nuclear explosion and from the French tests. The countrywide studies on fallout from French tests in the southern hemisphere have contributed information of significance to the understanding of the origin of monsoons. From the studies of countrywide fallout samples, it has been observed that the levels for different isotopes measured continued to decrease after the maximum values reached during 1963-64. The Division also carried out extensive measurements at Trombay to study the sources and concentrations of a number of atmospheric pollutants.

During the year, the countrywide radiation safety programme conducted by the Directorate of Radiation Protection expanded considerably. The film badge service run by the Directorate now covers some 16,000 radiation workers from about 1,250 institutions all over the country.

Fast Breeder Reactor

As a major step in the programme of developing fast reactors, the Atomic Energy Commission is planning to construct a Fast Breeder Test Reactor (FBTR) in collaboration with the Commissariat A L'Energie Atomique of France. An agreement for this was concluded early in 1969. A team consisting of Indian and French engineers, scientists and supporting staff worked during the year in France on the detailed design and drawings of the FBTR. A Design Review Committee consisting of senior staff from BARC operates from India. Simultaneously, civil works have commenc-

for Commercial Use

ed at the site of the new Reactor Research Centre by the side of the Madras Atomic Power Station at Kalpakkam, where the Fast Breeder Test Reactor will be built.

Work on the detailed report on an agro-industrial complex in western U.P. is nearing completion. Simultaneously, a study has been started of some of the important local conditions related to water and agriculture in western U.P. as well as in Saurashtra where a desalination unit may be advantageous.

Tata Institute

At the Tata Institute of Fundamental Research, Bombay, the on-line data processor (OLDAP) built in the Institute has been installed and fully checked out; it should soon be available as an on-line facility for analysis of bubble chamber film.

The 530-metre long cylindrical radio telescope at Ootacamund for studies in Radio Astronomy has been completed. It is a major facility for research in this area in India, and is one of the largest steerable radio telescopes in the world. Suitable for a systematic survey of weak extragalactic radio sources by the method of lunar occultation, it exploits fully the position of India near the geographic equator. The telescope in its mechanical and electronic aspects, has been entirely designed, and engineered in India.

The Atomic Minerals Division has intensified its underground development work at the Narwapahar and Bhatin mining prospects in Bihar. It has also located uranium and other atomic minerals in Rajasthan and the Himalayan ranges. The Uranium Mine at Jaduguda which the Division developed, and the Mill alongside it are being operated by the Uranium Corporation of India Ltd. (UCIL), a Government of India concern set up in October 1967.

Rare Earths

Also dealing with minerals, in this case rare earths minerals, is the Indian Rare Earths Ltd., another Government undertaking which was registered in August 1950. The company commercially exploits the mineral sands on the beaches of Tamil Nadu and Kerala States, operating plants at Alwaye, Manavalakurichi and Chavara. It is also operating the thorium plant at Trombay. During the year, IRE concluded an agreement with the United States for the sale of substantial quantities of rare earths.

In recent years a complex of plants have been programmed to support the expanding role of nuclear energy in the country. Among these are: the Nuclear Fuel Complex at Hyderabad which will prepare nuclear grade uranium oxide and cladding material for the country's nuclear power plants, a Power Reactor Fuel Reprocessing Plant at Tarapur and Heavy Water Plants at Rajasthan and at Baroda. The Heavy Water Plant at Rana Pratap Sagar will have a capacity of 100 tonnes a year. The plant at Baroda is being built by a consortium of French firms. Its capacity will be about 67 tonnes/year.

The Physical Research Laboratory at Ahmedabad, the Saha Institute of Nuclear Physics, Calcutta, and the Tata Memorial Centre, Bombay are among major units administratively responsible to the Department of Atomic Energy. The Physical Research Laboratory besides its investigations in aeronomy, geomagnetism, astrophysics, space physics, theoretical physics and related sciences, is doing pioneering work in space research. It has developed a number of instrumented payloads for launchings from Thumba and is collaborating with scientists from other nations in meteorological and other experiments from Thumba. The Saha Institute carries on basic research in nuclear physics. It is collaborating with the Bhabha Atomic Research Centre, Trombay, in setting up a Variable Energy Cyclotron for the Department of Atomic Energy in Calcutta. This cyclotron is being fabricated in India with some major components fabricated at BARC and at Indian firms such as the Heavy Engineering Corporation Ltd., Ranchi, and Heavy Electricals (India) Ltd., Bhopal.

Space Research

The Indian National Committee for Space Research (INCOSPAR) has been reconstituted with revised terms of reference under the Indian National Academy of Sciences of India, as the national body affiliated to the Committee on Space Research of the International Council of Scientific Unions. Since August 15, 1969, the national programme of Space Research and its utilization for peaceful purposes is being conducted by the Indian Space Research Organization (ISRO) of the Department of Atomic Energy.

The first India-built two-stage Centaure rocket, fabricated at BARC under licence from Sud Aviation of France was successfully launched on February 27, 1969 and its performance was found good. Collaborative experiments with Japan, USSR, Britain, France and West Germany are continuing from TERLS. A total of 77 rockets were fired from TERLS during 1969-70.

At the Space Science and Technology Centre of ISRO at Veli Hill, development of a series of rockets starting from a 75 mm diameter rocket and leading to a four-stage satellite launching vehicle with a 1000 mm dia. booster has been undertaken. Rohini 70, 75 and 125 rockets were successfully flight tested. So were the Menaka dart for meteorological studies and rockets with indigenously fabricated fibre glass bodies. A Rohini 300 mm diameter rocket is expected to be flight-tested this year. A feasibility and optimization study has been completed to finalize specifications for the design and development of a satellite launch vehicle having a capability of putting 30 kg. payload into 400 km. near-circular orbit. SSTC has been engaged in development work on materials and equipment for the overall space programme.

A Rocket Propellant Plant (RPP)

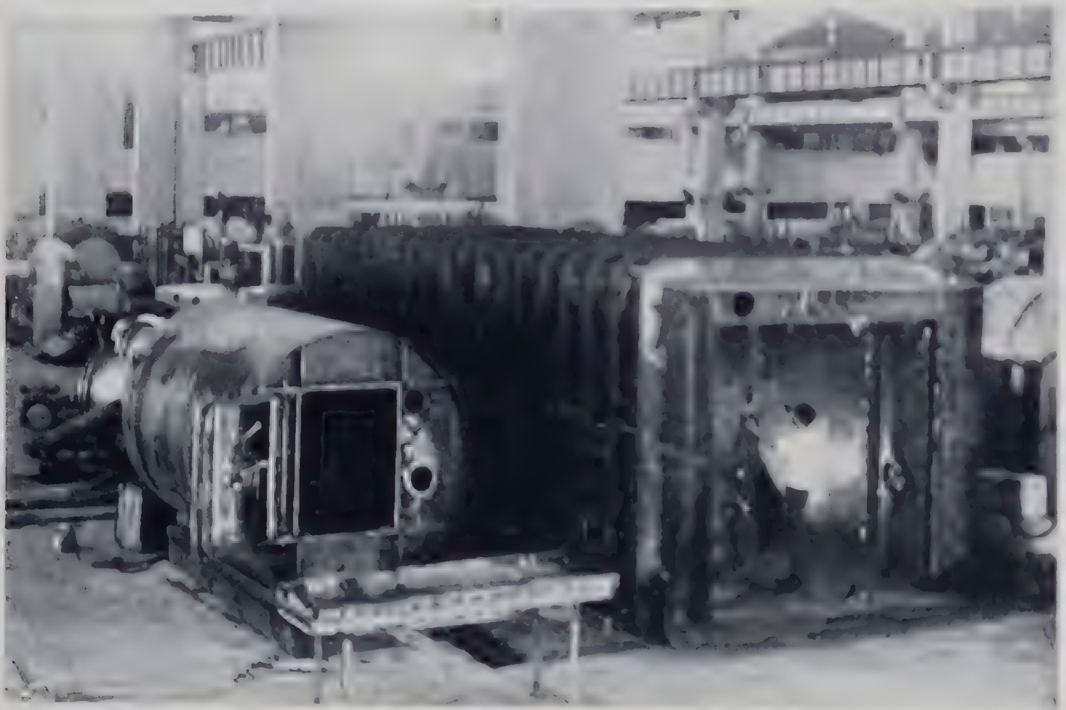
(Continued on page 8)

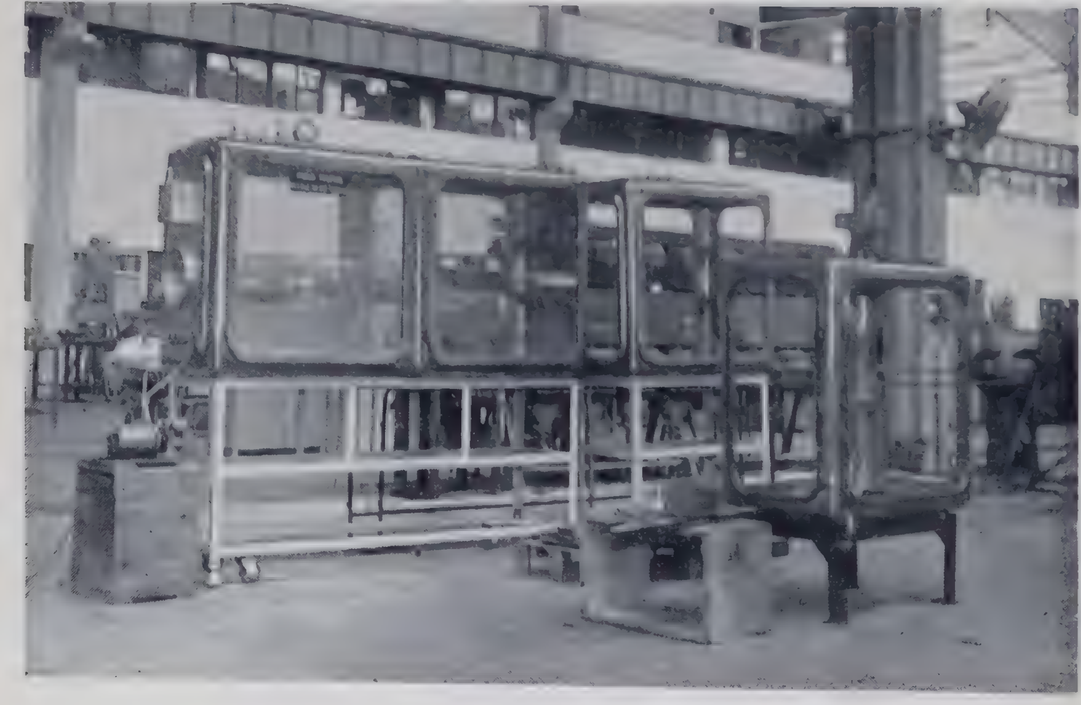
Above: A boring machine on which holes ove deep are bored in lattice tubes, about 700 which are under manufacture for RAPP-II. plicated tooling was developed at the W

Above left: Portion of a giant access doo fuelling machine vault at the Rajasthan Ato Project. The fabricated portion of each do around 20 tonnes. When filled with conc door weighs about 100 tonnes.

Left: A pair of air locks weighing anything tonnes for RAPP. The main air lock seen on above measures about 9 metres in length.

Below left: Stainless steel glove boxes for radioactive materials.





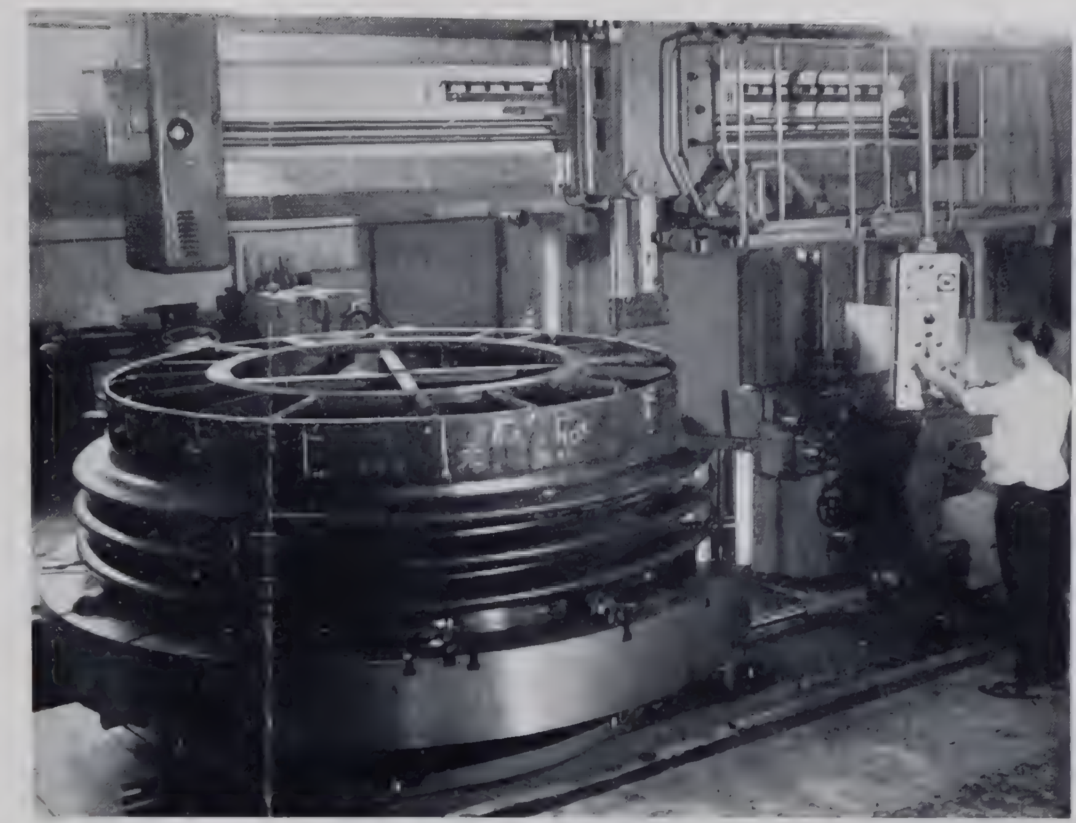
Equipment at Trombay

SELF-reliance being the keynote of India's nuclear effort, at an early stage of the programme certain engineering facilities were built into the atomic energy establishment at Trombay to support initial research and development work. Most of these major facilities grouped together and now known as the Central Workshops, have developed to meet a portion of the demands of India's nuclear power projects. The pictures on these pages will convey an idea of the versatility and capability acquired by the Workshops during recent years for manufacturing complex and precision-components.

The Central Workshops form a part of the Bhabha Atomic Research Centre. Their engineering activity spans a broad spectrum, from fabrication of stainless steel glove boxes, to the engineering of heavy, extra-large dimensioned reactor vault doors.

What this means in terms of skill and quality can be conveyed when it is stated that unlike conventional equipment, nuclear components cannot be approached easily for adjustment and repairs once they become

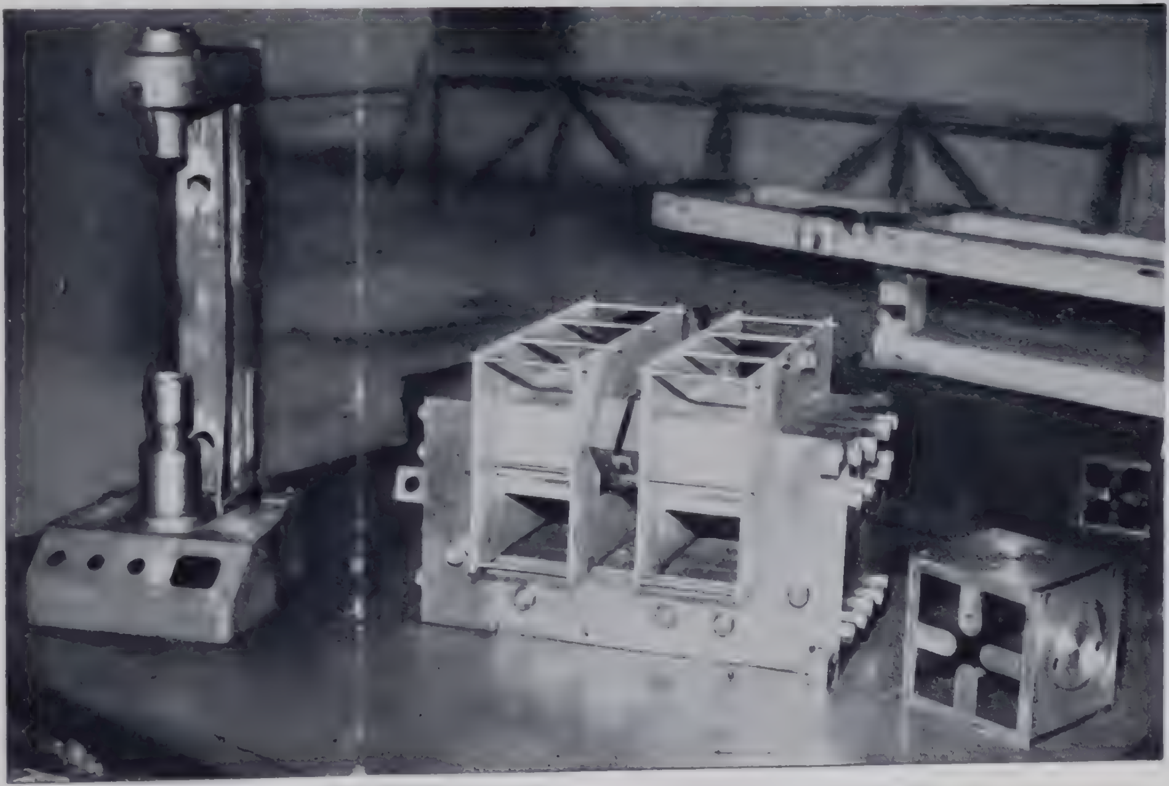
(*Continued on page 6*)



Above: A large expansion joint in stainless steel for RAPP-I being machined on a majestic single column "Berthiez" verticle boring mill.

Below (centre): Some of the stainless steel equipment being manufactured for the Zirconium Sponge Plant of the Hyderabad Nuclear Fuel Complex.

Below: A water base stem machine, an electro magnet and quadruple focussing lens made at the Workshops



Manufacture of Nuclear Equipment

(Continued from page 5)

part of the operational area without costly shut downs and radiation protection. Thus, at the very beginning of manufacture, stringent quality control has to be imposed as deviation from established specifications could be disastrous. Besides a built-in check and control system, engineering of nuclear equipment involves work with special materials and special tools demanding a high degree of skill on the part of the technicians and engineers. That many of the items presently being manufactured for the projects are being done for the first time in the country reflects the experience and confidence built up by the personnel.

Quality Control

In view of the critical nature of the equipment manufactured, stringent quality control measures are applied. The dimensional inspection is hundred per cent for all products and is carried out with precision instruments as also by means of non-destructive testing. To make doubly sure of the quality, the Central Workshops have their own captive Heat Treatment and Mechanical Testing Sections. Some of the mechanical testing equipment used for tensile, impact and hardness testing is calibrated to meet the standards of the American Society for Testing Materials. The testing laboratory at the Workshops has carried out tests even at sub-zero temperatures when required.

Among the earliest jobs executed at the Workshops for the Rajasthan Power Project were thermal shield lining plates collectively weighing several tens of tonnes. These plates involved accurate configuration work and considerable amount of welding as also work on the large planing machine in the Heavy Machine Shop.

Precision Work

One of the special features of equipment for Nuclear Power Projects is the association of bulkiness of their welded structures with the requirement for precision-machining. An example of this is the giant access door for the reactor vault at the Rajasthan Atomic Power Project. Moved hydraulically, the fabricated portion of the door weighs around 20 tonnes. When filled with concrete, its total weight would be about 100 tonnes. Four such doors are being made at the Central Workshops for the first and second units of the Project: two of these have since been delivered.

This door is an instance of precision work where the entire frame has been built-up by welding as per the procedures worked out on the lines of the rigorous codes of the relevant American/Canadian professional societies. A few of the doors machined parts demand an accuracy of half of a thousandth of an inch in certain cases. Between them, its various parts have to meet highly diversified tests such as magnetic particle crack detection, dye penetrant inspection, vacuum box leak detection and ultrasonic inspection.

Designing Tools

Machining of the reactor vault access door involves machining of surfaces of about 7 metres length to a fine surface finish. Precision machining of a gigantic piece like this involves many machining problems such as tool vibration, chip disposal etc. which have been successfully solved.

To meet special requirements, the workshops have improvised, designed and developed some tools to carry out intricate jobs of a special nature. An instance of one such unit is the tooling (for the deep hole boring machine) which was developed after extensive trials and experimentation. This machine is now being used for boring holes over 1000 mm deep in parts known as lattice tubes, about 700 of which are under manufacture for the second unit of the Rajasthan Atomic Power Project. This machine will also be employed for the deep hole boring of End Fittings in stainless steel (each more than 2000 mm long and weighing about half-a-tonne in forged state). Over 600 of these will be supplied for the second unit of the Rajasthan Atomic Power Project.

Nuclear Fuel Complex

In addition to meeting some of the needs of nuclear power plants, the Workshops are fabricating a number of items for the Nuclear Fuel Complex that is being set up at Hyderabad. Among these are about 200 different kinds of extra-large size items such as retorts, crucibles, tanks, etc. This involves argon arc or metal arc welding and machining of such materials as stainless steel 304L, 316, heat-resisting stainless steel 310 and alloys like inconel, between them, for the Zirconium Sponge Plant, the Zirconium Oxide Plant, and the Uranium Oxide Plant which will be among the units that will go to make the Hyderabad complex. The design temperature to which some of the retorts will be subjected will be over 1700°F.

Besides these major jobs, the Workshops continue to meet the orders of the various divisions of BARC.

Among the hundreds of jobs undertaken at the Workshops are included ultra high vacuum valves; machining on magnesium pipes; gold grain implantation guns and radiography cameras; gas analysers etc. The ultra high vacuum valves involve welding in stainless steel and scratchless mating surfaces for high vacuum. ●

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First National Conference on Electronics

ONE of the immediate consequences of the 1962 Chinese invasion was the exposure of the country's great dependence on foreign sources in electronics. This realization led the Government of India to appoint a Committee in August 1963 with Dr. Homi Bhabha as Chairman to review the state of electronics in the country, assess requirements over the next ten years and prepare guidelines for its all-round development.

The Bhabha Committee submitted its report in February 1966, a month after the demise of its Chairman. The Report was accepted by the Government in toto the same year.

During March 24-30, 1970, four years after the acceptance of the Report, representatives of the industry, Government ministries, universities, and scientific and technical institutions in the country met at the Tata Institute of Fundamental Research, Bombay, to review progress made on its recommendations. This, the first National Conference on Electronics, was organized by the Electronics Committee which was set-up in September 1966 to implement the Report. It drew nearly 500 participants who in all discussed around 90 papers in nine sessions, broadly under the following heads: Bhabha Committee Report, Industrial and Import Licensing Policies and Procedures, Foreign Financial Participation and Technical Collaboration, Research and Development, Role of Small Scale Units, Special Materials, Computers, Microelectronics, and Television.

Three Findings

In his opening remarks, Dr. Vikram Sarabhai, Chairman, Electronics Committee made a pithy summary of the picture of the field today vis-a-vis the recommendations of the Report. He pinpointed three findings which were broadly the general consensus. Firstly, that the entertainment sector has made the biggest progress and indigenous production of equipment in the sector has gone up. Targets have been exceeded but the prices of components or sets are rarely competitive against international standards. (2) There has been poor performance in attaining self-sufficiency in professional grade components and equipment particularly in areas such as Defence Electronics or in electronics for telecommunications, which are within the direct scope of Government initiative. (3) In basic raw materials, the country is far behind targets.

Handicaps of Committee

As Chairman of the Electronics Committee, Dr. Sarabhai acknowledged many of the shortcomings which have become apparent during these four years. Among them Dr. Sarabhai said was lack of an integrated and interlocked growth of the industry. A large part of the production of professional equipment is being manufactured under monopolistic conditions, there being no competition even among independent public sector companies. In spite of the industry being intensive in skilled personnel and having the advantage of a low salary standard compared to that prevailing in advanced countries, he said Indian goods rarely matched imported ones in price.

The Report had recommended that equipment be imported, dismantled and copied after modifications to suit Indian conditions. Not only had this not been done, but even specifications for the next generation of indigenous equipment needed had not been formulated.

Dr. Sarabhai explained that some of the reasons for the shortcomings could be attributed to the handicaps which the Electronics Committee was facing. If Government is to play a more effective role he said some of these elementary handicaps must be removed.

Among the major ones he noted is the lack of innovative leadership composed of people with technical judgement and commitment to a long range task of growth. There is also a total lack of primary data on production, sales, imports, research and development activities. Not only is little data available but even that has to be collated from a large number of agencies which made no effort to ensure that rapid retrieval was possible. Moreover, he said, the sources collected data on the basis of self-generated categories with the result that intercomparison between them became impossible.

Dr. Sarabhai stressed that a technologically and commercially meaningful evaluatory function could be achieved only when scientists and engineers, actually engaged in design, development and engineering activities were involved in the examination of applications for industrial licences. In a fast growing industry like electronics with a doubling time of 2-3 years, he said targets of licensed capacity should represent minimum levels to be reached rather than limits within which production must be framed. And further, he emphasised, foreign equity should be limited to no more than 50 per cent if a business in this country were to play a full role of development. Electronics is the one industry he said where India could make a big breakthrough just as Japan did, domestically, and in exports. Indeed, Dr. Sarabhai declared, India could do better for it had a much bigger potential domestic market where it could regulate operations.

Stress on R & D

Inaugurating the Conference, Dr. B. D. Nag Chaudhuri, Member (Science), Planning Commission, said there appeared to be inadequate appreciation of the speed of technological change or the steps necessary to escape obsolescence without taking on the cost-burden of rapid replacements. If groups responsible for electronics development did not incorporate R & D in the component industries or if laboratories did not have access to these industries he said there could be serious danger. Past lessons showed that imported know-how without local R & D backing got obsolete very fast and increased costs, he stressed. For appropriate development of electronics he said there

(Continued on page 8)

Report on 1969-70

(Continued from page 3)

for the manufacture of composite solid propellant grains was commissioned in February 1969. A Rocket Fabrication Facility (RFF) is also being built at Thumba for undertaking fabrication of vehicles and accessories for the Rohini vehicles now under development at the Space Science and Technology Centre. This facility is expected to be commissioned by the middle of 1970.

A rocket range is being established at Sriharikota in Andhra Pradesh. This facility, which is expected to be ready in six months time, will be used as a sounding rocket launching facility and for flight testing of new rockets being developed at the Space Science and Technology Centre.

NASA-DAE Agreement

A most important step forward in the space programme is the conclusion of an agreement for collaboration with the National Aeronautics and Space Administration of USA for a Satellite Instructional Television Experiment which entails the use by India of NASA Satellite ATS-F for about one year around 1973 to diffuse television programmes made in and originating from India to 5,000 community television sets located in rural areas of some selected regions. Direct broadcast of T.V. signals to augmented receivers will be tested for the first time through this experiment, which will also provide experience for linking conventional T.V. rediffusion stations in a national hook-up using a synchronous satellite. Many agencies of the Government of India, particularly, AIR, will be involved in the project.

The Experimental Satellite Communication Earth Station is engaged in building the Arvi Commercial Satellite Communication Earth Station, a task that is being undertaken by an Indian team for the first time. The Station is also engaged in conducting its regular training courses in satellite communications technology for personnel from India and other developing countries. ●

First National Conference on Electronics

(Continued from page 7)

should be appropriate R & D programmes. It is an area where one has to run quite fast to stay exactly in the same place. In Japan and the USA and a few other countries where there is a large electronics industry, or in countries like France which is building up a fairly large electronics industry, the R & D effort in electronics is a very large fraction as compared to other industries, sometimes upto 9 per cent of the total sales in electronics as compared to .5 per cent to 1.5 per cent in the case of steel.

Dr. S. Bhagavantam stressed that the whole philosophy of working towards self-sufficiency in the field of electronic equipment implied that detailed design specifications and reasonably firm quantity requirements would be furnished by the users to the designer/producer at least five years ahead. In many areas, particularly defence, this may seem difficult but all attempts should be made at the highest level to insist on such exercises being gone through.

The universities which are the places where R & D activities can be promoted are quite weak in India. The Electronics Committee, he said, had taken some steps in this direction and funded a few projects. A technical group of the Committee had looked into this to locate institutions and individuals for assigning work on an ad hoc basis. The industry too he said was being encouraged to set apart funds for research and development and build adequately equipped laboratories. Much remained to be done in this work and till this weakness on R & D side was removed, he said dependence on foreign knowhow might continue for a long time.

Speaking on promotion of industrial research in electronics, Shri A. S. Rao, Director, Electronics Group of the Bhabha Atomic Research Centre pleaded for urgent measures to step up R & D expenditure to the recommended level, if not more. He pointed out that even then the size of India's R & D effort would be meagre in comparison with those of the advanced countries, and so careful selection of R & D projects and massive effort above the "threshold level" would be necessary, if the country were to bridge the technology gap. New research laboratories initiating programmes in the most advanced areas of electronics technology must be built around capable and outstanding scientists. He emphasised the need in Government administrative departments of a correct appreciation of the role of R & D in electronics and of their commitment and wholehearted support to the work of the scientists and engineers. ●

SEMINAR ON POLLUTION AND HUMAN ENVIRONMENT

A seminar on Pollution and Human Environment will be held at the Bhabha Atomic Research Centre, Bombay in August this year. Open to participants from the industry, government agencies, state and municipal bodies, and individual experts, it will provide a platform for focussing public attention on the problem of growing environmental pollution in the country.

The seminar was decided upon at a meeting of the Working Group on Human Environment constituted under the direction of the Committee on Science and Technology of the Cabinet held at the Bhabha Atomic Research Centre, Trombay on May 7 and 8, 1970.

Sponsoring organizations and specialists in pollution studies may kindly send their nominations indicating the area of specialisation to Dr. A. K. Ganguly, Head, Health Physics Division, Bhabha Atomic Research Centre, Bombay 85 (AS) so as to reach him by June 30, 1970. A few travel grants are available if financial assistance is needed for participation.

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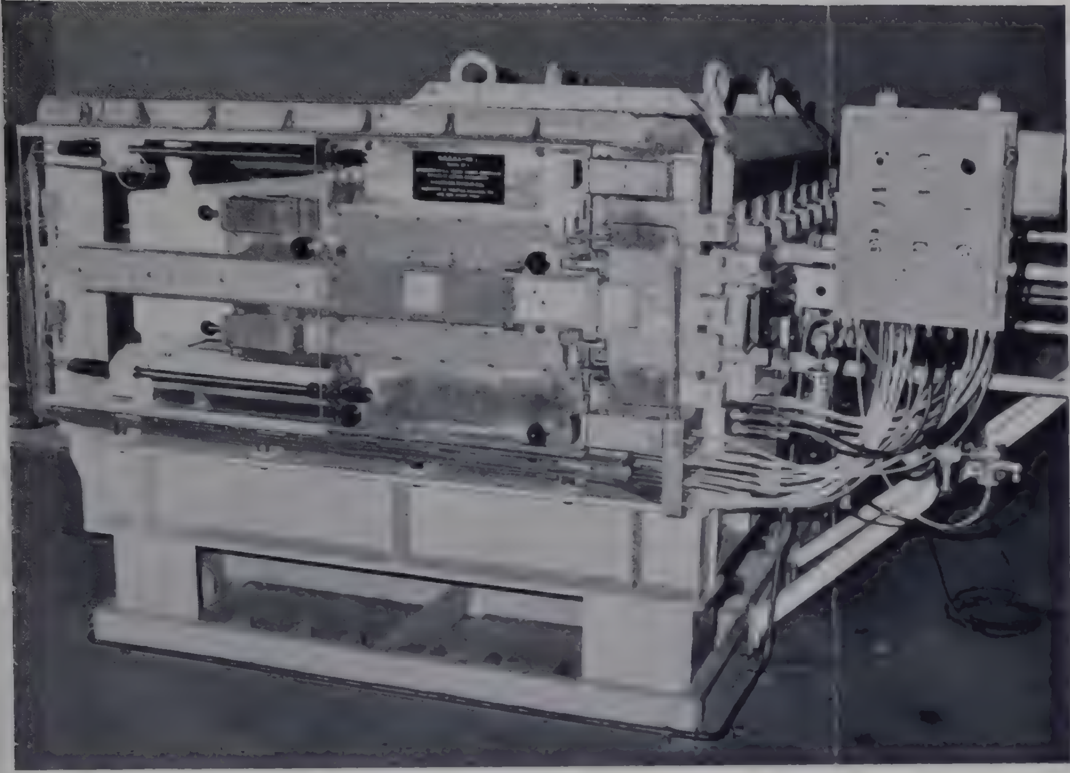


Caesium - 137 Irradiator at Trombay

A PORTABLE caesium^{137} irradiator has been installed at the Food Irradiation and Processing Laboratory of the Bhabha Atomic Research Centre at Trombay.

Obtained from the Brookhaven National Laboratory, USA, the irradiator will be used for studies relating to radiation preservation of foods and other perishables, and associated research work. It was received under a bilateral agreement, with the United States Atomic Energy Commission.

Self-Contained

The irradiator is a self-contained lead-shielded unit with a 108,000 curies Cs^{137} source. The source moves horizontally from, and back, to its stored position after each radiation cycle. The irradiation chamber is provided with two doors located directly over and under the source. It can hold about 45 kg to 70 kg of the product to be irradiated. The chamber and source cask are mounted on a structural base which can also be anchored to a moving platform such as the deck of a ship. The source plaque assembly and the shielding doors — comprising the moving parts of the irradiator — are powered and controlled by compressed air.

After dose distribution studies in the product carrier box, the irradiator will be used for extension of work on projects relating to pasteurization or preservation of sea foods, poultry and other flesh foods, fruits and vegetables, etc., for disinfestation of cereal products and premixes; and other research work. After initial trials at Trombay, the irradiator is proposed to be set up in a coastal area where organized facilities exist for improved catch handling, and storage of sea foods. This will permit use of much smaller doses of radiation for increasing their shelf-life. ●

10-Year Programme For Atomic Energy, And Space Research

A TEN YEAR programme — for 1970-80 — has been proposed for atomic energy and space research by Dr. Vikram Sarabhai, Chairman of the Atomic Energy Commission. Dr. Sarabhai outlined the programme at a press conference in New Delhi on May 25. If the proposal is taken up, by the end of the decade the country would be generating 2700 MWe of power from nuclear stations and will have expanded support facilities. The power plan would mean the approval of three new nuclear power plants with a total capacity of 1,500 MWe. The programme includes development of gas centrifuge technology for U235 enrichment, construction of a large 500 MW prototype fast breeder test reactor, establishment of a large reactor research centre and other associated units. In the area of Space Research, the programme would place the country in a position to launch 1200 kg. payloads into synchronous orbits by 1980.

For the growth of nuclear power, the original targets suggested in 1954 by the Department of Atomic Energy were :

600 MWe by 1970-1971
3000 MWe by 1975-1976
8000 MWe by 1980-1981

In 1965 the Energy Survey of India Committee forecast :

600 MWe of nuclear power by 1970-1971
2000 MWe of nuclear power by 1975-1976;

(Continued on page 3)

Environmental Pollution

Trombay's Approach

On May 7 and 8, the Working Group on Human Environment constituted at the instance of the Committee on Science and Technology (CoST) met at the Bhabha Atomic Research Centre, (BARC) Trombay, to take stock of the extent of pollution in the country and fix priorities for tackling the problem. The meeting was convened by Dr. A. K. Ganguly, Head of the Health Physics Division of the Centre. This Division looks after safety aspects of operations in nuclear installations in the country, and safety in the environment. The meeting was convened to get together the various agencies involved in pollution control and management — governmental as well as non-governmental, universities and eminent individuals who are actively interested in the control of pollution. As a follow up to this meeting in August this year, a national seminar on environmental pollution is being organized at BARC. What follows is an excerpt of the welcome address at the meeting by Shri H. N. Sethna, Director of BARC in which he describes the Centre's approach to this problem and the efforts made to minimize environmental pollution as a result of atomic energy operations.

IN our country unattended pollution has spread so uncontrollably, that unless we sit down to take stock of the situation dispassionately and scientifically, we might altogether miss the very cause that needs remedial action. It will call for objective judgement to assess a situation, balance the risks and benefits, and see the merits and defects of a location and control processes.

In this country, since independence, we have advanced technologically in many respects. Our industrial production in every sphere has increased — metals, chemicals, pesticides, petrochemicals, textiles, agricultural produce, tanneries and of course electrical power. We are told that we have achieved near self-sufficiency in food. All these mean extensive releases of chemicals to the environment — toxic gases to air; chemicals and detergents to the rivers and seas; fertilisers and pesticides to soils; land run-off and organic wastes to public streams.

Industrial expansion has drawn the working class population to urban areas leading to a disproportionate development of human settlements and slums in the cities, creating complicated and uncontrolled municipal problems. We have an enormous strain on fresh water and all the cities are starved of adequate fresh or clean water supply. People live in unhygienic conditions with improper and inadequate sanitation adding progressively to pollution and disease.

Excellent Record

The BARC representatives will present their experiences of environment management at Trombay, at Jaduguda where we run a uranium mine and a mill and at Tarapur where a year of nuclear power generation is successfully over. There are several good reasons why the atomic energy industry in the country and elsewhere has an excellent record of pollution control and wastes disposal. Our approach is different, our permissible discharge standards are stringent and our site selection criteria are restrictive.

Our primary control lies in establishing exclusion areas round the nuclear installations. The extent of the exclusion zone depends upon the nuclear processes carried out in the installation — but the basic assumptions are that no one outside the exclusion zone should be exposed above the safe permissible limit of exposure.

The very philosophy of waste management — gaseous, liquid and solid wastes is one of containment on site. According to us, wastes once discharged are irretrievable and it might be impossible to trace all the persons exposed to pollution even with diligent surveillance techniques. Under no circumstances can wastes discharged be above permissible limits. If there are no releases to the environment, there is no pollution. I am not making an idealised statement when I talk of no releases to the environment if that can be engineered to be contained as the most practical solution to control environmental pollution. In fact, we are presently developing a major metallurgical and chemical complex, handling radioactive toxins and chemical pollutants — fluorides, nitrates and sulphates and ammonium salts in the wastes, without any pollution of the surrounding areas.

Elaborate Process

We have a different approach at other sites where total containment is not possible or where there are reasonable facilities for safe minimal discharges. On a site being available for installing a nuclear plant, we carry out studies on water and wind movement, demography of the site *i.e.* population distribution, utilisation of site etc., and then specify the safe limits of releases to the environment — to air and water. This is an elaborate process; water movement studies are carried out with dyes and tracers, the ecology of the area is studied in the field and the laboratory to establish concentration factors along the food chain using stable isotopic trace elements, uptake by adsorption on silt and sand are determined etc. Micro-meteorological parameters are determined for frequencies of wind direction and wind speeds and rates of deposition. At all sites we have established micro-meteorological laboratories for this purpose with high research towers. In all the cases, natural and fallout activities may be used as tracers. A figure for the discharge limit is then arrived at on the basis of recipient capacity which is further reduced to allow for synergistic effects from other radioisotopes, and to allow for other pathways of exposure — such as by inhalation, ingestion and direct exposure. The chemical treatment processes and the fixing of absolute filters and special chemical filters are then programmed to meet the preset small limit of release through all the escape routes — even sometimes at very heavy costs.

(Continued on page 8)

Dr. Sarabhai's Programme for Development

(*Continued from page 1*)

5000 MWe of nuclear power by 1980-1981

More recently the plans proposed by the Atomic Energy Commission were the following:

In addition to the two units at Tarapur (380 MWe), two units at Rajasthan (400 MWe) and the one unit at Madras (200 MWe), one more unit at Madras (200 MWe) was suggested. It was also proposed to have 1500 MWe scheduled for completion by 1979 so that by the end of the Fifth Plan, a total of 2700 MWe of nuclear power could be installed. The present position however is that while the second unit of the Madras Station has been approved, the other units proposed have not been approved.

Firm Commitment

Dr. Sarabhai contended that from the point of view of nuclear power strategy, immediate approval of the additional installed nuclear power capacity proposed by him is of great importance, for the average time-lag between approval of a project and its going on stream should be between five and six years. Unless decisions regarding three 500 MWe units are taken immediately, it would not be possible to complete them by the end of the Fifth Plan. He maintained that a firm commitment to a nuclear power programme for a ten-year period (in the present case to have an installed capacity upto 1980 of 2700 MWe) is of prime necessity for making sustained progress in R & D as well as for the industrial infra structure. A major R & D effort would be the indigenous design and development of 500 MWe advanced thermal reactors using natural uranium with slight plutonium enrichment to permit the use of light water as a coolant.

An important factor which will influence costs of nuclear power projects in India would be the introduction of enriched uranium in the Indian programme using the gas centrifuge process. This involves not only sophisticated chemistry and machine technology, but also materials such as carbon filaments which are strong and corrosion resistant.

Among the important features of the programme spelled out by Dr. Sarabhai are:

(a) 2700 MWe of nuclear power to be commissioned before 1980. This means approval for three new power stations with total generating capacity of 1500 MWe. Construction of these should start during the Fourth Plan.

(b) Design and construction of advanced thermal reactors of about 500 MWe unit size which would lower the capital cost of power stations while still producing plutonium for future needs in fast breeder reactors.

(c) Completion of fast breeder test reactor and experience with technology of plutonium enriched fuel, its fabrication and reprocessing, sodium coolant technology and experience with thorium-bred U 233 fuel.

(d) Augmentation of heavy water production to about 300 tonnes per year to back-up the programme for the use of natural uranium in the power reactors.

(e) Design and construction of a large 500 MW prototype fast breeder test reactor.

(f) Development of gas centrifuge technology for U235 isotope enrichment. Development of special materials including carbon filament structures.

(g) Development of the Narwapahar Uranium Mines and facilities for extraction from low grade ore. Also development of processes for the extraction of ore from tailings in copper mines.

(h) Early completion of the Nuclear Fuel Complex to manufacture special materials and fuel elements for the programme.

(i) Widespread application of isotopes in industrial processing, food preservation, sterilization of medical products, medicine and research.

All these will not only require creation during the Fourth Plan of one major new atomic energy research establishment, namely the Reactor Research Centre at Kalpakkam, which should have a complement of about 3000 to 4000 by the end of the decade, but also personnel for manning the new projects of industrial importance. One of the most important aspects for the success of the atomic energy projects would be the development of a new integrated organization involving the interests of public and private sector organizations in industry, which would be involved in fully backing up the programme in all its phases — from the production of raw materials to the fabrication of specialized equipment, and the erection and commissioning of major plants within a stipulated time frame.

New Resources

During the Fourth Plan alone, the establishments of the Atomic Energy Commission will generate new resources of about Rs 45 crores through power and goods manufactured for sale to outsiders. Such has been the difficult position of resources that the allocations which were required for the Fourth Plan by the Department of Atomic Energy have been drastically cut in the sectors of Industry and Minerals as well as for Atomic and Space Research. A commitment to the programme would involve a restoration of most of these cuts during the next three years of the Fourth Plan.

Space Research Programme for 1970-80

The space research programme involves the following:

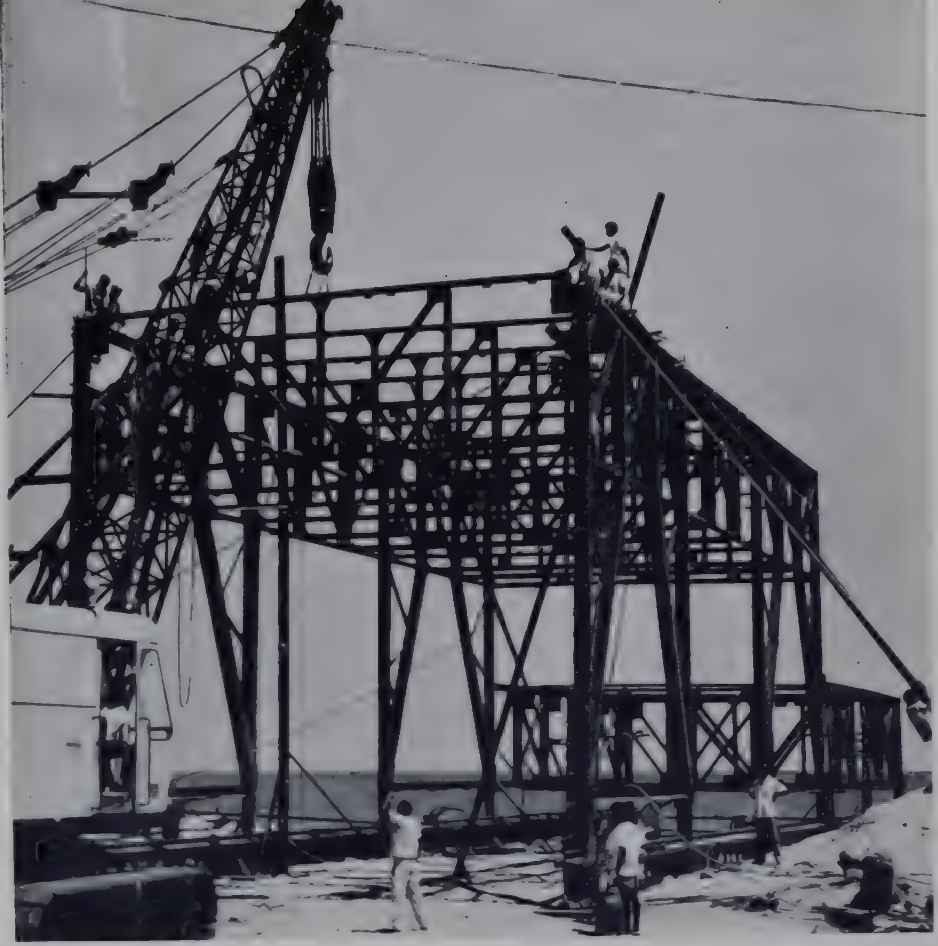
(a) Augmentation of the facilities for R & D at the Space Science and Technology Centre to be able to build scientific and communication satellites and to environmentally test them.

(b) Facilities at the Space Science and Technology Centre for the development of inertial guidance systems and on-board miniaturised computers.

(c) Development at Space Science and Technology Centre, Tata Institute of Fundamental Research, Bombay,

(*Continued on page 7*)

Left : *Reinforcement grill being lifted for positioning in the excavated trench for the reactor building diaphragm wall.* **Centre :** *View of the 43-m diameter diaphragm wall for Reactor Building of Unit No. 1.* **Below :** *Prestressed concrete bridge across the Edaiyur backwaters. Far right : Travelling platform for construction of access jetty being erected.*



Kalpakkam—India's Third Nuclear Power Station

by M. R. Srinivasan
Chief Construction Engineer
Madras Atomic Power Project

THE third nuclear power station in India is being built at Kalpakkam on the east coast of India, about 60 kilometres south of Madras. This site is very close to Mahabalipuram, once a centre of great artistic activity in India and from where maritime trade with countries of South East Asia flourished. This project has a special importance in the nuclear power programme of the country as it marks the coming of age of the programme as full responsibility for the execution of the project, including design, engineering and construction rests with Indians. A twin unit station using Candu type reactors, each with an output of about 200 MWe is planned and work has commenced on the first unit.

This station will feed into the power system serving the State of Tamil Nadu. The installed capacity available to the system at present is 1600 MWe, of which 969 MWe is from hydro and 631 MWe from thermal stations. By the time the Kalpakkam station starts operating, the installed capacity will be 2615 MWe with a hydroelectric capacity of 1434 MWe and a thermal capacity of 1181 MWe supplied from coal and lignite fuelled stations. The Madras system has interconnections with the systems of adjacent States and bulk transfer of power is a regular feature at present. In the past, the Madras system has suffered serious dislocation during years of drought due to excessive dependence on hydro stations. The cost of coal is high as it has to be transported over distances of 600 kms. or more. These considerations have favoured installation of a nuclear power station in the region.

While the basic features of the reactor system adopted for Kalpakkam are similar to those of the Rajasthan reactors, a number of changes are being incorporated for reasons of economy or due to conditions special to the site. In this article some of the more important changes that have been considered for adoption at Kalpakkam are described.

In the case of the Rajasthan reactors and the Douglas Point reactor which has served as a prototype from which designs for the Rajasthan reactors are derived, post-accident safety has been achieved by adoption of a dousing system. This consists of a large tank of water placed inside the reactor building at the highest elevation. Through fast acting valves, water will be allowed to flow past areas where gases and vapours may accumulate following an accident, thus resulting in condensation and subsequent pressure reduction. For the reactors at Kalpakkam, however, the containment building will be constructed to withstand the maximum pressure following a maximum cred-

The Third Atomic Power Plant in India

(Continued from page 5)

ible accident without resorting to dousing. It has been estimated that the maximum internal pressure in such an accident condition will be about 1.16 kgs. per square centimetre. The reactor containment building will be constructed in prestressed concrete with a wall thickness of 60 cms. From considerations of radiation protection it has been found necessary to have an additional shielding wall 71 cms. in thickness. This shielding wall is being constructed as a separate free standing wall outside the prestressed wall of the reactor building. There is an annular gap of 107 cms. The gas in the annular space will be vented in a controlled manner so that the release of radioactivity to the environment in the event of an accident would be reduced significantly. The double containment principle is expected to be particularly advantageous for future locations where it may become necessary to site nuclear power stations closer to population centres or load centres.

The elimination of dousing however gives rise to possibility of hazards to occupational personnel who may be in the reactor building at certain locations which require to be manned during the operation of the reactors. To overcome this problem, a pressure suppression pool is being incorporated in the basement of the reactor building and the hot gases and vapours from the reactor boiler rooms are arranged to pass through the suppression chamber. With this arrangement, it is estimated that the pressure and temperature conditions in the portion of the reactor building where operating personnel may be present would be kept down to 0.48 kg. per square centimetre at 32.2°C.

Good Foundation

Certain features of this site have favoured the adoption of the above design features. The site has in general an over burden of sand for a depth of 9 to 12 metres on an average, overlying a granitic gneiss, geologically classified as charnokite. The rock is fine to coarse grained granite and is capable of withstanding heavy foundation loads. The sub-soil water level is however rather high (can be as close as 1.5 to 2.9 m. from the surface) and open excavations of large sizes would involve expensive dewatering techniques. The technique of continuous cast diaphragm wall using bentonite slurry has proved very successful and in this manner a diaphragm wall 61 cms. thick with an internal diameter of 42.97 metres is being constructed for each of the two reactor buildings. This wall enables the construction of the prestressed concrete wall of the reactor building to be taken up essentially in dry conditions. In addition, the diaphragm wall will also support the shielding wall which envelopes the prestressed concrete perimeter wall.

Coastal Locations

The arrangements proposed for drawing the cooling water from the sea at Kalpakkam are of particular interest. It may be mentioned in passing that we have been constrained to select either coastal locations or locations near hydro electric/irrigation storage reservoirs for the nuclear power stations under construction in India as it is difficult to obtain large quantities of cooling water from the rivers, as most of the rivers in India have extremely low dry weather flows though they may have very large flood flows. Use of cooling towers though attractive from the point of view of investment cost, poses a penalty in efficiency and this is particularly serious for the water reactors which inherently have a limitation on the thermodynamic efficiency that can be obtained. It is for these reasons that both the Tarapur and Kalpakkam power stations have been located on the sea shore.

The east coast of India is characterised by very large littoral drift and it is estimated that at the Madras coast roughly about a million tonnes of sand and silt move across a given section in a year. The littoral drift is known to extend to about 8 metres depth of water. This coast is also visited by cyclones of high intensity practically every year in the months of November/December.

A number of alternative methods of obtaining the cooling water were considered and these included pipes laid on the bed of the sea, pipes supported on a submerged jetty structure and syphon pipes supported on a jetty connected to a pump house on shore, pressure pipes supported on an elevated jetty with the pump house in the sea, and lastly a submarine tunnel connected to an intake structure in the sea and a pump house on shore. The choice was finally in favour of a submarine tunnel connected to an intake structure located approximately about 500 metres from the high water line. In this design the coastal regime is not interfered with and also major components of the intake system are not exposed to the hazards of cyclonic conditions. The tunnel which will be common for both the units of the power station will be driven about 22 metres below the bed rock and will terminate in an on shore vertical shaft joining with the pump house.

Approach Jetty

Construction of the intake structure in the sea presents some problems. There are no harbour facilities in the vicinity of the site and the nearest such facility is at Madras which is about 60 kilometres from the site. Floating craft with shallow draft and high lifting capacity cranes are not available easily in India. These factors have led to a solution wherein it is proposed to construct the intake structure entirely from the land. For this purpose an approach jetty approximately 500 metres long is being constructed. The jetty will consist essentially of a single row of piles of 1.22 metres diameter spaced at 15.24 metres intervals. The jetty will support a road-way about 3.660 metres wide. The jetty will not only enable the construction of the intake structure in the sea but will also provide a main-

(Continued on page 7)

Major Portion of Kalpakkam Will Be Indian

(Continued from page 6)

tenance access to the intake structure.

The coastal currents near the site have been studied and it is observed that the general pattern is that the current flows from south to north for about 6 months in a year from March to September, and from north to south for the rest of the year. The design of the outfall structure for the cooling water has to ensure that there is no possibility of the hot effluent flowing towards the intake. For this purpose a multi-baffled open channel outfall is proposed wherein the discharging water will be directed in phase with the prevailing coastal current so that the hot effluent is carried well away from the intake structure.

Salt Contamination

The switchyard will be located about 300 metres from the sea. While some protection will be afforded by the reactor and turbine buildings located on the seaward side of the switchyard, contamination of high voltage insulators from salt spray may not be eliminated fully. In order to overcome this problem various alternatives including the possibility of an enclosed switchyard are being studied. Experiments at site are afoot to determine the intensity of salt deposition on insulator stacks, suspension and strain insulators. The extent of protection that may be afforded by buildings and by a growth of tall trees which would act as shielding against salt spray will also be studied.

We may now look at the procurement of equipment required for the power station. Orders have been let out to Indian fabricators for the fabrication of the calandria, end shields, end shield rings, dump tank, shield tank etc. The primary circuit pumps required for circulating the heavy water through the reactors will also be manufactured in India. The fuelling machines will be made by the Bhabha Atomic Research Centre. The control and instrumentation will be supplied by the Electronics Corporation of India Ltd., a company under the Department of Atomic Energy. The zirconium alloy components, namely the calandria tubes, pressure tubes, and fuel sheathing will come from the Nuclear Fuel Complex of the Department of Atomic Energy being set up at Hyderabad. The uranium dioxide fuel pellets will also be produced at Hyderabad. Heavy water required for the Kalpakkam reactors will come from the heavy water plants in India.

On the conventional side also practically all the equipment will be of indigenous origin. Thus for example, the turbine generator, the main transformer, the large circulating water pumps, condenser, etc., will all be supplied by Indian manufacturers. In relation to these conventional equipment new demands are being made regarding increased sizes; for example the turbine generator with a rating of 264 MVA will be the largest of its kind to be made in the country. This is also true of the circulating water pumps. Indeed the design of the systems has had to be adapted suitably to accept the sizes and capacity of equipment that can be produced indigenously.

Transport

A brief mention may be made about the problem of transportation of some of the heavy and over-dimensioned components to the site. Though the proximity of the Madras harbour to Kalpakkam and the existence of a

(Continued on page 8)

10-Year Atomic Energy, Space Research Plan

(Continued from page 3)

and Electronics Corporation of India Ltd., Hyderabad, and construction of high performance missile tracking radars and POM communication systems for installation at Shri Harikota Range (SHAR) and at Andamans in the Bay of Bengal for the satellite programme.

(d) Construction of a plant for manufacture of large solid propellant blocks at SHAR and a facility for static testing of these propellant blocks on the ground and under high altitude simulated conditions.

(e) Completion of a rocket fabrication facility at Trivandrum for manufacture of large size rocket casings and hardware for rocket motors including the development of special materials for rocket motor systems.

(f) Development of in-flight guidance systems for rockets.

(g) Development by 1973-74 of a "Scout" type launcher which would be of four stages, burning solid propellant, capable of putting into orbit a satellite of about 40 kg. payload. This would be followed by development of more advanced rocket systems capable of putting 1200 kg. payloads into synchronous orbits.

(h) Fabrication of communication satellites by 1975 capable of providing high quality point to point service between metropolitan areas and direct broadcast of television.

(i) Development of sensors and techniques for remote sensing.

The constraints on the development of space technology are related to the development of men and teams familiar with new sophisticated technology. With a growth rate of about 50 to 100 per cent per year, it still needs about three years before India can reach the minimum critical size for successfully implementing large scale projects of space technology. ●

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Environmental Pollution — BARC's Approach

(Cotinued from page 2)

Most of these studies are carried out in the preoperational stage of the plant long before the plant has gone into operation. A preoperational environmental survey laboratory operated for example for four years at Tarapur before the reactors were commissioned. The advantage of this method was that we had acquired sufficient knowledge of the site to control pollution and apportion the total capacity of the environment to handle any increased release of contamination without effecting the general population.

I have limited my comments to environmental pollution control rather than containment management. We have made advances here in the treatment of industrial effluents and development of absolute filters and respirators and the techniques are available for national use.

I have gone at length to summarise our environmental approach because this is novel to conventional industry and because industry and pollution experts may look upon their own management methods from a new angle. Our approach is that environmental pollution is an extension of operational responsibility.

Indian Standard Man

The basic criteria for evaluation of radioactive pollution in the nuclear environment are the recommendations of ICRP* who have set safe permissible limits of concentration of radionuclides in air and water. These are primary standards. But these are standards evolved for a Western Standard Man weighing 70 kg, breathing 18 M^3 air/day and drinking 2 litres/ of water per day. The average Indian weighs less than 50 kg, his air intake is nearly 25 M^3/day, his water intake is 4 litres/day. We take these variables in adopting our safety standard and take into consideration the differences in average organ weights for dose calculations.

To a limited extent we carry out thermal and noise pollution studies though the latter is more in the working environment such as in an ore crushing mill rather than in the general environment. Nuclear reactors again adopt conventional turbines for power generation and reject nearly 65% of the heat generated to the environment. We have undertaken studies of heat dissipation in the coastal waters at Tarapur and in the inland waters of the Chambal river at Rajasthan.

If I may summarise: rapid industrial expansion to raise the standard of living of our people without adequate attention to the raising of the standard of human settlements and pollution control has led to uncontrolled, unhygienic and insanitary conditions in the country. The indiscriminate growth of population in areas unplanned to receive this population has led to the growth of slums and uncontrolled pollution. We must try to halt the prevailing condition, create an awakening to develop ideally located, self-contained units, re-use waste water and plan colonies to avoid contamination of the general environment, and of large drinking water supplies and coastal waters.

Let me end with a warning: It is said that bacteria that convert sugar into alcohol through an excretary process die in their own excreta when the concentration goes up. ●

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* *International Commission for Radiological Protection.*

Kalpakkam Nuclear Plant

(Continued from page 7)

good road between Madras and Kalpakkam have mitigated the problems in comparison to those faced by the Rajasthan Atomic Power Project, the fact that many of the heavy and over-dimensioned components have to move from fabricators located in the interior of the country has meant an intensive survey of the transport capability from these locations. In many instances improvements to the road system and overcoming of infringements for rail transport have had to be taken up.

Many Challenges

The execution of the nuclear power project at Kalpakkam therefore poses many challenges over a wide range of technology. In the area of civil construction, the prestressed concrete containment building and the submarine tunnel will be executed for the first time in the country. In the area of fabrication of equipment and manufacture of components all the specialised equipment and components required for the nuclear portion of the plant including those using special materials are being taken up by Indian industry. So far as conventional equipment are concerned, new demands regarding increased sizes or special performance features are being placed and industry is being encouraged to fulfil these demands. It will thus be seen that the execution of this project will act as a pace setter and catalyst to technological developments which would be invaluable in the realisation of a large nuclear power programe in the country in the years to come. ●

Corrigendum

We regret the name of Sir Jagadish Chandra Bose was left out in the list of Indian Fellows of the Royal Society carried in the May issue of "Nuclear India". Sir J. C. Bose was elected FRS in 1920. Prof. M. G. K. Menon thus becomes the 18th Indian FRS.

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Arvi Satellite Station Nearing Completion

21.12.70

TOWARDS the end of this year, a little village called Arvi some 80 km. north of Poona will become a centre of India's international telecommunications with the world through a satellite.

Arvi was chosen as the site of India's first commercial satellite communications earth station a few years ago. The station will link up with the Intelsat III satellite which was launched over the Indian Ocean in July 1969 for a 72-nation International Telecommunications Consortium. The Consortium, of which India is a member, was formed in 1964 to establish and operate a global communications system. Three synchronous satellites placed on the equator 120° apart, around the earth, at an altitude of approximately 36,000 km, will provide near-world coverage for telecommunication purposes. The Consortium provides the space segment (the satellite being the most important constituent) while the member-countries provide the ground segments which consist chiefly of the earth station, international maintenance centre, intercommunications systems etc.

Three Repeater Stations

The Arvi Satellite Communications Project, known as the "ASCOM Project" is being executed by the Department of Atomic Energy on turnkey basis for the Ministry of Communications. The 8-crore earth station complex includes the station, the wide band microwave link between Arvi and Bombay (with three repeater stations enroute, at Giravali, Chikli and Matheran) and the terminal installation (Videsh Sanchar Bhavan) in Bombay. The microwave signals from Matheran, the last repeater station, will be picked up by a parabolic antenna installed on top of the 17-storey Videsh Sanchar Bhavan.

A view of the 29.5 m diameter antenna at the Arvi Satellite Communications Station.

The Arvi Station is located in a bowl, with hills on all sides, some 2 km. from the Arvi village proper. The station has a 29.5 m. diameter steerable parabolic antenna weighing some 300 tonnes for receiving and transmitting signals to and from the satellite. The servo and drive system controlling the movement of the antenna has been designed to keep pointed to the satellite very acurately even in winds upto 100 km. per hour.

The station will have the capacity to handle 600 telephone, telegraph (telex) channels, facsimile, television, both pictures and high quality sound, and could work with 12 international destinations.

The Intelsat satellite with which the station will work is a geostationary communication satellite positioned at the equator about 36,000 km. above the earth at latitude 62.5° east. The satellite receives radiowaves transmitted from the earth stations, amplifies them and retransmits the signals to the receiving earth stations.

The ASCOM Project is estimated to cost Rs. 5.25 crores (inclusive of customs duty) with approximately 50 per cent in foreign exchange for the imported equipment. The indigenous

(Continued on page 3)

The Purpose of a Research Reactor

A discussion of the NRX and CANDU reactors

A RESEARCH REACTOR is used to study the effect of nuclear radiation, particularly neutrons, on matter. Certain experiments can be carried out with radiation from "sources" such as isotopes, but a reactor is necessary to provide massive doses of neutrons or to breed the isotopes themselves.

A large reactor of the NRX type serves two distinct types of experiments, pure and applied. "Pure" research into the nature of matter includes the disciplines of nuclear physics, solid state physics, biology and health physics, and so on. Much of this kind of research can be carried out with much smaller reactors or with particle accelerators. The special advantage of a large and powerful reactor is that it can be used as an engineering materials test reactor while serving a host of pure research experiments at the same time.

The basis of the design of NRX and its successors is that the reactor vessel is in the form of a calandria — a cylindrical vessel penetrated by a large number of tubes parallel to its axis. These tubes are vertical in NRX; heavy water fills the calandria, and fuel rods with coolant passing over them at high velocity occupy the tubes. This configuration has been the basis of every Canadian reactor ever since. The total separation of moderator and coolant has many advantages which are applicable to power as well as research reactors. In the NRX design, light water is the coolant but the small volume of water does not preclude the use of natural uranium. In the NRU variation, heavy water is used as coolant, which increases the available neutron flux. But this increases the capital cost.

Intensity of Flux

The effectiveness of a reactor is measured by the intensity of the neutron flux available to the experimenter. This is not the same as reactor power, which is measured in kilowatts of heat. The materials experimenter is interested in blasting the maximum number of neutrons through his sample in the shortest possible time for life tests. For example, he may want to know the effect of irradiation on a component which must last for the life of a power reactor. If he has access to a research reactor which has fifty times the flux of a power reactor, he can irradiate a sample for six months and give it the same "integrated dose" as it will experience in practice in twenty-five years.

Interdependent Effects

This ability to test materials is vital to a country wishing to establish an autonomous nuclear programme. It is impossible to design a reactor without a thorough knowledge of the way its components will stand up to the combined effects of radiation, heat, corrosion and stress. Designers quickly learned that these four effects are inter-dependent; for example, the phenomenon known as "creep" can only be studied properly if the sample is irradiated at the same temperature and the same stress as the component will undergo in practice. It is unwise to attempt to extrapolate the behaviour of materials from experiments carried out on very small samples.

If we confine ourselves to the larger engineering-test reactors, there are two basic types. The pool-type reactor has an open, easily accessible core at the bottom of a deep tank. Fuel, experimental samples, test loops, instruments, etc. are lifted in and out of the core by direct manual manipulation from above. The pool water is continuously circulated through heat exchangers to dissipate the heat. The core glows a brilliant blue when in operation and is a spectacular sight. The operators and observers down into the pool are fully protected from radiation by the shielding properties of the water.

The tank type of reactor, of which NRX is one, is totally inaccessible during operation and is surrounded by many feet of shielding steel and concrete. In-pile experiments, including fuel testing, are mounted in the core while the reactor is shut down. Beam tubes lead radiation to an experimental area outside the shield; these experiments are set up and checked for safety before the reactor is started up. A typical operating regime at NRX might be 5 days shutdown followed by 25 days at power.

There are advantages and disadvantages to both these reactor types. As recently as 1966 the French commissioned a 50 MW reactor of the pool type. However, there is one fundamental difference which affects the choice. Because the pool reactor uses ordinary (light) water which is used as moderator, coolant and radiation shield, the fuel must be uranium of a fairly high enrichment. There will be a continuing requirement for enriched fuel during the life of the reactor. The heavy water moderated reactor, on the other hand, can be designed for either enriched or natural uranium fuel, and can even become a near-breeder. Natural uranium has great advantages for a country which would like to mine indigenous uranium and manufacture its own fuel.

NRX and CANDU

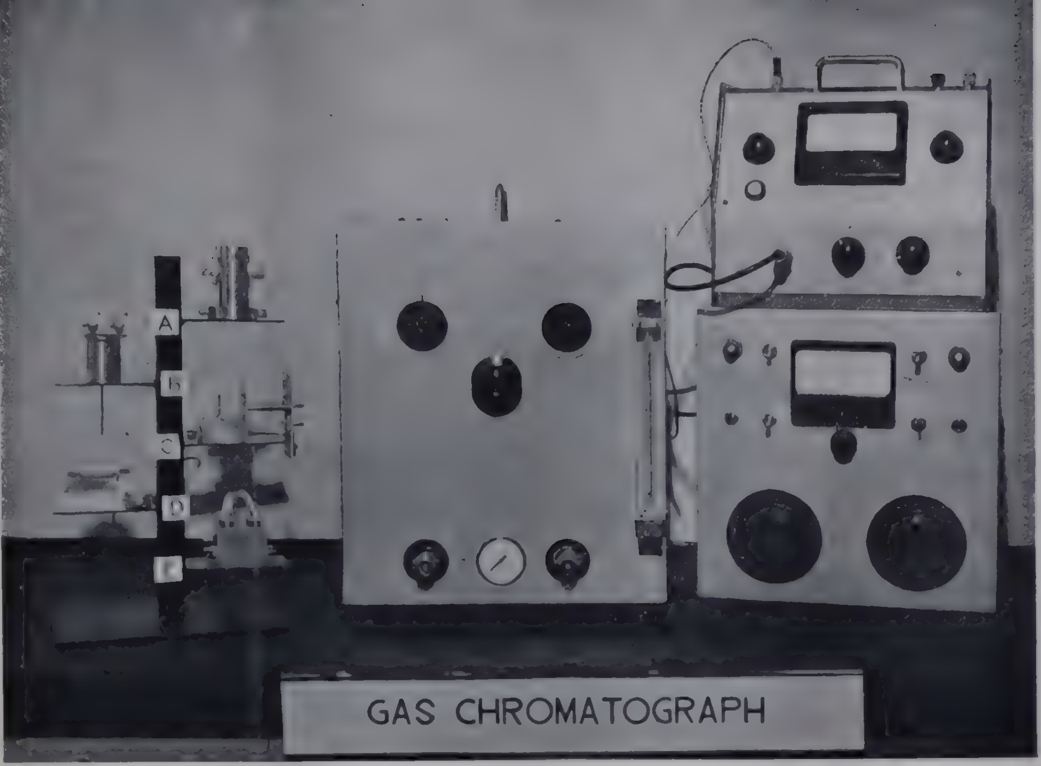
Another interesting comparison is that whereas the pool type of reactor has nothing in common with a power reactor, the NRX reactor has nearly all the features of the CANDU reactor. In CANDU the fuel is completly different because of the vastly higher power density, but apart from this, the principles of calandria, primary circuit, moderator cooling, and so on are identical. Hence a country acquiring a research reactor of this type has an excellent test bed and also a training tool for a nuclear power programme of CANDU reactors.

(From "Nuclear Canada", March 1970)

Gas Chromatograph Developed at BARC

THE Chemistry Division of the Bhabha Atomic Research Centre, Trombay, has developed and released the knowhow for manufacture of gas chromatographs in the country.

Gas chromatography is a method for separating components of mixtures of volatile compounds. The application of this technique is widespread. Gas chromatographs are already monitoring and controlling major processes in chemical and petroleum industries. The technique has revolutionised research in organic chemistry and is used extensively in studies of air pollution, insecticide residue, food flavour and odour etc. Samples need be only a fraction of a microlitre. The speed of analyses is such that multi-component mixtures can be separated in a few seconds. Gas chromatographs can be used for practically all classes of substances — from permanent gases to high molecular weight non-volatile ones.



BARC-developed gas chromatograph.

The Centre is also offering additional items for sale on a non-exclusive basis. These include: (i) four filament thermal conductivity detector — a general purpose detector suitable for both organic and inorganic samples including permanent gases; (ii) Electron Capture Detector — a selective detector of extremely high sensitivity for compounds of high electron affinity such as halogenated compounds, pesticides, lead alkyls, nitro compounds etc; (iii) β ray ionisation detector — a highly sensitive detector for organic compounds; (iv) Flame ionisation detector — the most widely used detector for organic compounds because of its high sensitivity and wide linear response; (v) pyrolyser attachment — thermally decomposes solid non-volatile materials like paper, plastics, rubber, paints, etc. into volatile breakdown products which can be analysed in a gas chromatograph. The resulting pyrograms are characteristic of the substance pyrolysed. Details of these items can be obtained by writing to the Director, Bhabha Atomic Research Centre, Trombay. ●

Arvi Satellite Station Nears Completion

(Continued from page 1)

constituents of the earth station complex include the Antenna System, the Servo and Drive System for the antenna, the Multiplex Equipment Power Supply System and all the Civil Engineering Works besides System Engineering and Project administration functions.

The indigenous portion of the project has been handled by the following organizations :

i. ASCOM Project Organization.
ii. The Experimental Satellite Communications Earth Station at Ahmedabad.
iii. Electronics Prototype Engineering Laboratory, Trombay.
iv. Bhabha Atomic Research Centre.
v. Trombay Township Project.
vi. The Indian Telephone Industries.
vii. A number of private/public sector engineering organizations.

To meet the foreign exchange requirements for the imported equipment at the Station, Canada has given India a loan of 4 million Canadian Dollars (approximately Rs. 2.8 crores). The electronics for the earth station complex has been supplied by M/s. RCA Ltd. Montreal, Canada.

Wg. Cdr. K. R. Rao, Director, ESCES, Ahmedabad is the Project Administrator of the ASCOM Project. The Overseas Communications Service will handle the necessary interconnection activities between the international and domestic communications systems, and will operate the Earth Station Complex. ●

Symposium

A symposium on "Radiation and Radioisotopes in Soil Studies and Plant Nutrition" organized by the Food & Agriculture Committee of the Department of Atomic Energy will be held at the University of Agricultural Sciences, Hebbal, Bangalore 24, during December 21-23, 1970. The last date for sending the abstracts for the contributed papers is September 30, 1970. The abstracts should be sent to Dr. K. B. Mistry, Biology Division, Bhabha Atomic Research Centre, Trombay, Bombay 85.

AVF Cyclotron at Calcutta: the VEC Project

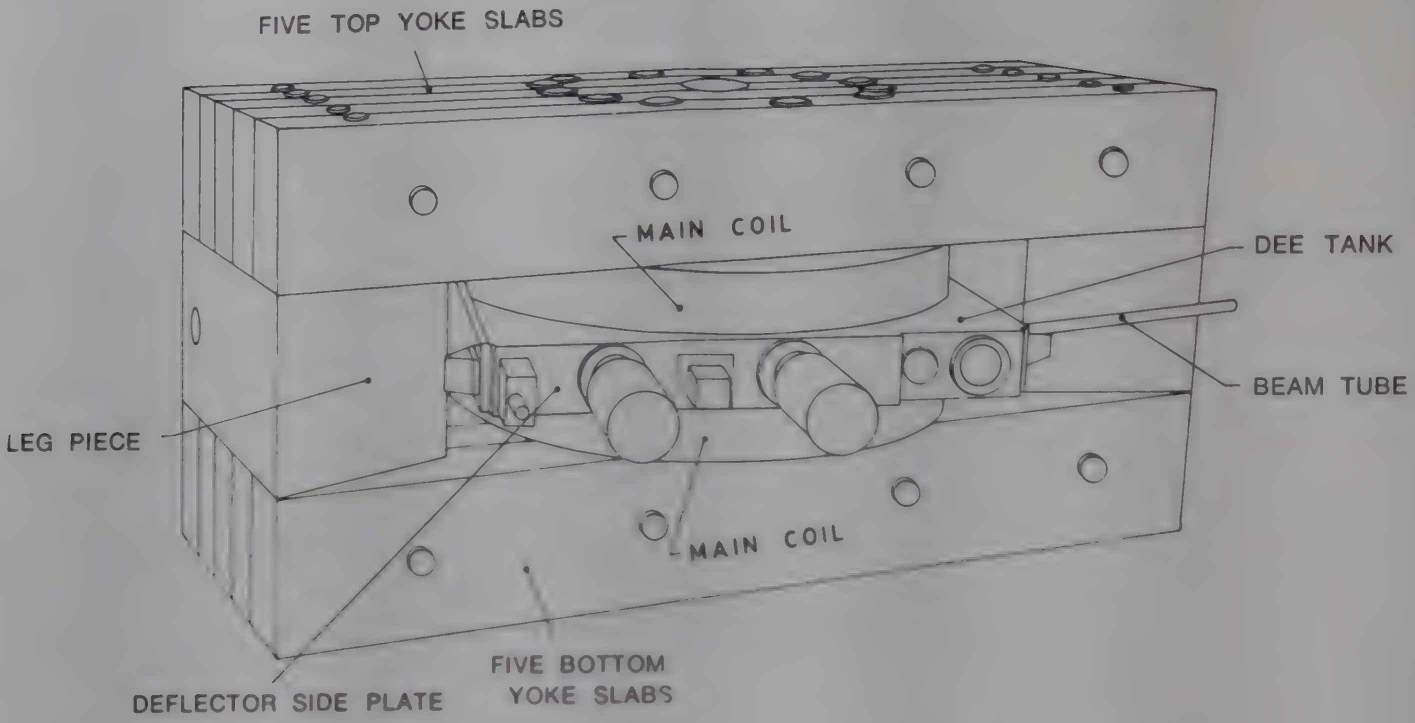


Fig. 1. The cyclotron magnet and dee-tank assembly.

By A. P. Thatte

Variable Energy Cyclotron (VEC) Project, Bhabha Atomic Research Centre, Trombay.

A SIGNIFICANT part of our knowledge of nuclear physics has been obtained from research work carried out using cyclic accelerators, called cyclotrons. In a cyclotron, the value of alternating electric field governs the energy gained by the particles per revolution, whereas the number of revolutions depends on the strength of the magnetic field.* High energy cyclotrons, therefore, require giant-sized magnets, producing fields of upto 20,000 gauss over large areas covered by particle orbits. At energies beyond about 25 MeV for proton, the frequency of applied alternating electric field also needs to be swept periodically over a small range to maintain isochronism.

An alternative technique has subsequently been developed by which a fixed frequency cyclotron can yield a proton beam of energy in excess of 25 MeV limit. Using a set of auxiliary coils, called the trim-coils, the magnetic field is made to increase towards the periphery of the circular pole face. The consequent defocussing tendency of the circulating beam is corrected by dividing the pole-gap azimuthally into alternate regions of strong and weak fields, created by attaching sector-shaped steel pieces over the pole faces of the magnet. Hence the name AVF (Azimuthally Varying Field) Cyclotrons given to such machines. The pole-gap between hill-sectors is, therefore, small (strong field), and large (weak field) between the remaining areas (called valley regions) of pole faces. Machines using the AVF property for acceleration and focussing of the beam are, therefore, sometimes also called 'sector-focussed cyclotrons'.

Magnet System

The magnet for the Calcutta AVF cyclotron has an H-shaped core. The overall dimensions of the assembled magnet are: 6.10 m long x 2.9 m high x 2.24 m wide. The steel frame weighing about 262 tonnes, is made up of 14 major parts. Thus, during machining and assembly of the magnet frame, individual parts weighing upto about 20 tonnes would have to be handled. Steel having a low carbon (0.12 per cent max.) and silicon (0.35 per cent max.) content would be used. The manufacture of the magnet frame, involving low porosity faultless casting and machining to close tolerences of many big-sized steel blocks, has been contracted to the Heavy Engineering Corporation at Ranchi. The estimated cost of the magnet, including the price of steel, would be about Rs. 42.5 lakhs.

Five rectangular slabs, clamped together with four horizontal bolts, make up each of the top and bottom yokes (See fig. 1). Another set of verticle bolts further ties these slabs to the leg pieces, which are slightly tapered to accommodate probes. A hole of 20.3 cm diameter would also be made in each leg along its central horizontal plane to provide a line of sight through the magnet centre along the dee edge (See fig. 2, page 5).

Sector-focussing Poles

The two cylindrical pole pieces are 2.24 m in diameter and 32.1 cm high. They are bolted to the upper and lower yokes by a third set of bolts. A 22.86 cm diameter hole through the pole pieces and the middle slabs of

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* See "Cyclotrons for Nuclear, Research" Nuclear India, Vol. 7, No. 2, Oct. 1968.

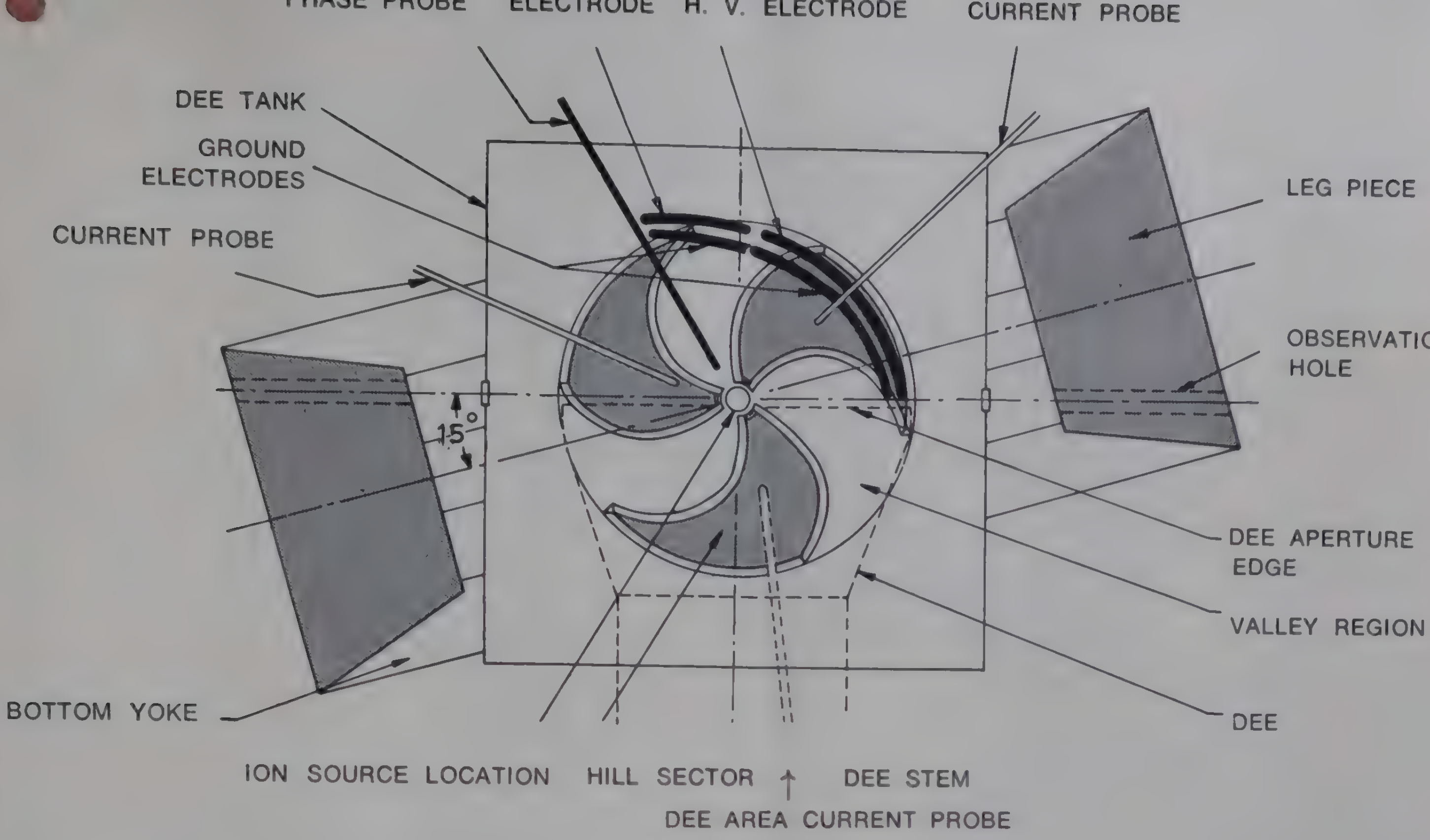

Fig. 2. Plan view of the accelerating region.

the yokes enable insertion of the ion-source either from the top or from the bottom of the magnet along the verticle axis through the machine centre.

Two sets, each of three symmetrically spaced steel hill-sectors of spiral shapes as shown in fig. 2 are attached to the two 8.9 cm thick and 223.8 cm diameter circular steel discs called valley floor plates. The spiral hill-sectors, each 5.46 cm thick and weighing about 580 kg, would be machined from forged steel blocks. The valley floor plates are in turn bolted to the pole pieces, so that the pole-gap between the top and bottom valley floor plates is 29.97 cm. It reduces to 19.05 cm in the areas covered by the hill-sectors.

Coils

The azimuthally varying magnetic field in the Calcutta Cyclotron would be generated by two sets of energising coils — (1) main coils and (2) an assembly of trim and valley coils. The basic uniform magnetic field of 17.1 kilogauss (max.) is to be produced by 560,000 ampere-turn main coils, weighing about 10 tonnes. Their outside diameter is 2.99 m. The imported copper conductor to be used for the main coils would be of 2.858 cm square cross-section with a 1.588 cm diameter hole in the centre for flow of cooling water. The maximum DC through the conductor would be 3,000 amperes.

Fig. 3 (p. 6) is a photo of the 1/5 scale model of one of the two trim valley coil assemblies to be used in the Calcutta Cyclotron. It consists of a 49-turn flat pancake of 17 independent concentric trim coils, each having from 2 to 4 turns. Each pancake has three groups of 2, 4 and 11 coils, circulating DC upto 2500, 2000 and 750 amperes respectively. Hollow copper conductor, 1.111 cm square and 0.755 cm hole for carrying water, would be used for trimcoils. It would be wrapped with semica-therm tape and anchored by suitable brace clamps over a copper base-plate having precision machined locating grooves. The pancake would then be further potted with epoxy.

There are three sector-shaped valley coil assemblies, each of five coils mounted over each of the two circular trim-coil pancakes (See fig. 3). The circulating DC through the water-cooled, hollow copper tubing of valley-coil conductor would be 350 amperes. Each of the two trim-valley coil assemblies is bolted over the steel pole faces of the magnet in such a way that the copper base-plates of trim-coil pancakes face the dee from either side. Since these assemblies are contained in a vacuum enclosure surrounding the dee, the electrical and water connections would be taken outside through special vacuum-tight terminations on two sides of the assembly as seen in Fig. 3.

A contract for fabrication of the main and trim-valley coil assemblies has been awarded to the Heavy Electricals (India) Ltd., Bhopal. The estimated cost is about Rs. 16.73 lakhs.

Power Supplies

The DC power supply unit for the main magnet coils would deliver upto 3000 amperes highly regulated current at 175 volts, smoothly variable by SCR control. Individual variable power supply units would feed DC to each of the seventeen trim coils. Two units would deliver 30 volts 2500 A, 4 units 24 volts 2000 A, and 11 units 11 volts 750 A. Transistor banks would be the

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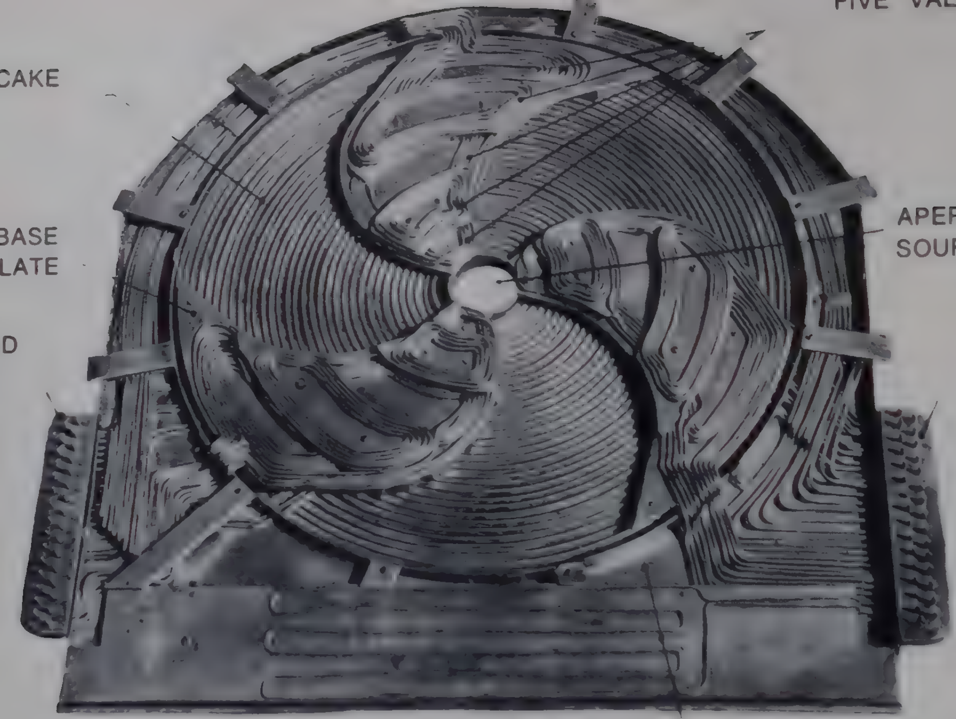
FIVE VALLEY COILS
TRIM COIL PANCAKE
VALLEY COIL BASE PLATE
APERTURE FOR ION SOURCE
VACUUM SEALED TERMINATIONS
VACUUM SEALED TERMINATIONS
WATER-COOLED COPPER BASE-PLATE

Fig. 3. 1/5 scale model of the trim-valley coils assembly.

series regulating devices. A single variac-controlled unregulated power supply unit giving 350A DC at 15 volts would energise the valley coils. Another unit using SCRs and series transistors for 0.001% controlled output of 160 volts 500A DC, would energise the analysing magnet. Similarly two 150 volts 300A DC SCR controlled power supply units would feed the two switching magnets. 0.1% transistor regulated 30 volts 300A DC power supplies would be used for the quadrupole magnets. All these power supply units are being manufactured in BARC.

Ion Source

A PIG type source, giving ion-currents upto 5 mA, would be installed in the central hole of the pole piece attached to the bottom yoke of the magnet. For efficient extraction of ions, the source is used in combination with a puller electrode attached to the tip of the dee. In a variable energy machine, the orbit radia change for different settings of the magnetic field. An appropriate movement to change the location of the ion source with respect to the puller electrode is, therefore, necessary. That would be realised by independent rotation of two eccentrically nested cylinders. The complete ion-source, its drive mechanisms and power supply units are being fabricated in BARC.

Deflector

For optimising the conditions for efficient acceleration and extraction, the ions moving outwards from the centre in a spiral orbit are monitored by three current probes, located 120° apart and by a phase measuring probe (See fig. 2). The accelerated particles are finally extracted by an electrostatic field between a pair of deflector electrodes. Like the ion-source, the deflector electrodes also need to be moved for optimum extraction of the beam at various energies. Fig. 4-b (page 8) shows a photograph of the 1/5 scale model of the deflector assembly to be used in the Calcutta cyclotron. One of the three water-cooled extraction electrodes would be at ground potential, another would be at 120 kV DC while the third section is usually left floating. Their ends could be moved by a system of linkages. The non-magnetic inconel alloy base-plate has a cantilever support from a side panel of the dee-tank (See figs. 1 & 4-b). Electrical and mechanical connections to the deflector electrodes are brought out through vacuum sealed stainless steel bellows and ceramic insulated bushings. The Cockraft-Walton circuit for generating the high DC voltages for the deflector is immediately behind the dee-tank.

A quarter scale model, reproducing the geometry and motion of the deflector electrodes, would be kept in the control room. Visual indications for adjustments are obtained by driving the slave selsyns of the model with sending selsyns of the actual deflector. The model also provides place for mounting microswitches to limit the movement of high-voltage electrode against an accidental short.

The deflector assembly, extracting the high energy beam from the cyclotron gets maximum radio-active contamination. A 4-wheel truck moving on rails in the vault of the Calcutta cyclotron would facilitate occasional removal and storage of the 'hot' deflector assembly.

The Dee

The Calcutta cyclotron would use a single dee covering half of the circular area under the two 223.5 cm diameter pole faces of the main magnet (see fig. 2). The 0.94 mm thick

(Continued on next page)

allo[illegible]re lined with 0.76 mm thick copper sheets on the outside and 4.76 mm thick graphite sheets on the inner sides facing the circulating beam. The structural supports are also of k-monel alloy. The total maximum RF heating of the dee, amounting to about 5 kW, would be removed by water-cooling. The rectangular aperture at the dee edge is 3.81 x 218.5 cm. The dee plus the dee-stem forms a quarter-wave resonant transmission line to which the oscillator output is capacitively coupled at an appropriate point. The RF voltage at the tip of the dee would be 50 kV (rms) maximum, giving a maximum energy gain of 140 kV/turn to the revolving charged particles.

RF System

The RF oscillator of the Calcutta Cyclotron would have a maximum power of 300 kW. The anode voltage of 20 kV for the super-power oscillator tube (RCA 6949) is regulated by a series tube (ML 7560), which also serves as a high speed disconnect. A set of movable corrugated copper panels on either side of the dee-stem behave electrically equivalent to a co-axial transmission line of variable inductance. That, together with the fixed self-capacitance of the dee with respect to its surrounding vacuum enclosure (called the dee-tank) forms the tuned circuit load for the oscillator tube. The movable panels are mounted in a steel resonator tank which is 2.43 m wide, 3.25 m long and 2.90 m in height (See fig. 4-a). By taking them away from, or nearer to the dee-stem, the inductance of the transmission line changes to enable the operating frequency to be varied at full power over a range of 5.5 to 16 MHz. The dee and dee-stem assembly, weighing about a tonne, as well as the movable panels are water-cooled.

The RCA 6949 oscillator tube, mounted in a cabinet outside the resonator tank, is self-excited via a fore-shortened half-wavelength grid transmission line. The grid coupling loop, situated besides the dee stem inside the resonator tank, picks up most of the RF fringing field from the closed-in panels at the high frequency end. For the low frequency operation, when the panels are away from the dee-stem, the grid loop has very little coupling. For stabilising the operating frequency to 1 part in 10^5 at any value within the operating band, an additional independent locking signal would be impressed on the RCA 6949 tube grid. A crystal controlled, high stability, low power oscillator would give an output of about 2 V(rms). A pre-amplifier stage (output 70 V, rms) followed by a broad-band power-amplifier stage of 1 kW output will make that signal serve as an external sync for the RCA 6949 oscillator tube. The sync frequency would, of course, be variable over the same range as the main oscillator and displayed by a digital frequency meter in the control room.

A low-conductivity water-cooling system would be provided to circulate de-mineralised water through the hollow copper conductors of the various magnets and the copper tubes cooling the dee, dee-stem, resonator tank panels as well as the super-power oscillator and series tubes.

Vacuum System

A rough vacuum would be created in the 20 cubic meter resonator tank surrounding the dee-stem and carrying the moving panels, using a 1000 litre per sec Root's blower backed by a 135 litre per sec rotary vacuum pump. Afterwards two 89 cm diffusion pumps having freon refrigerated chevron baffles, evacuate the system further to the desired operating pressure of the order of 5 x 10^{-6} torr with a dynamic leak of upto 5 cc per minute of gas introduced in the ion-source. These pumps, each having an unbaffled pumping speed of about 40,000 litres per second, also evacuate the smaller (3.25m x 3.15m x 0.39m) dee-tank through a rectangular opening in the side of the resonator tank. They would be backed by 65-litre-per-second rotary pumps. Provision would also be made for attaching another small auxiliary pump, when required, near the extraction electrode region. Pneumatically operated gate-valves would be used for isolating the pumps. A number of smaller pumping stations would also be used at intervals along the beam tubes through which the accelerated ions would be carried for various experiments. Quite a few major parts of the vacuum system for the Calcutta cyclotron are being fabricated in BARC.

Beam Transport System

A versatile beam-transport system, consisting of two switching magnets, one analysing magnet and several pairs of quadrupole magnets, would be provided to facilitate precision experiments using the extracted beam of high-energy charged particles from the cyclotron. Two experimental areas would be provided on either side of the vault housing the cyclotron. One high intensity low resolution area of 175 square meters will accommodate three beam channels in separate caves and the other high resolution low intensity area of 585 square meters will have 6 beam channels in three caves.

Data remotely collected by instruments in the caves would be processed in the two counting rooms on either side of the main control room. They would be equipped with scalers, multi parameter analysers, an on-line data processing computer etc., to be supplied by the Electronic Corporation of India Ltd., Hyderabad.

Control System

To protect the cyclotron operators and users from radio-activity associated with high energy charged particle nuclear reactions, the vault and the caves would have a biological shield of thick concrete walls around them. An elaborate remote control sysem, incorporating a number of chains of various electrical and mechanical interlocks, would be used for controlling a variety of equipment and services feeding the cyclotron as well as for optimising the settings of a number of its components. The Indian Telephone Industries, Bangalore, would supply and install the relay racks containing over a thousand control relays operated from control-room commands.

Building

The Calcutta Variable Energy Cyclotron would be installed in a

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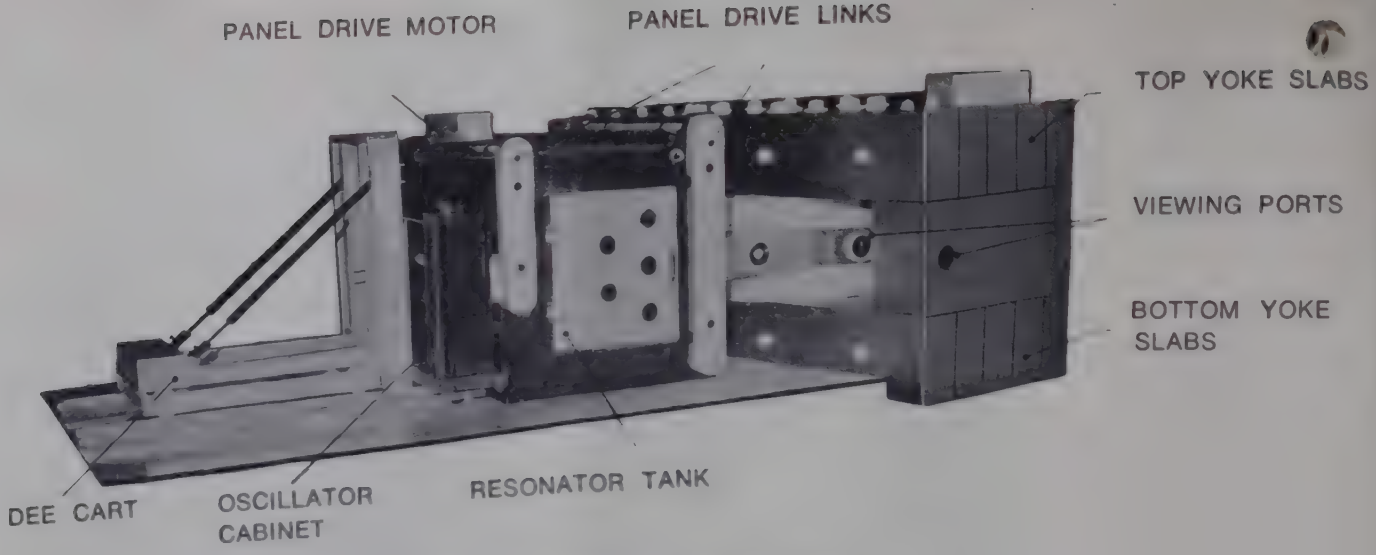

Fig. 4a. View of a model of the machine.

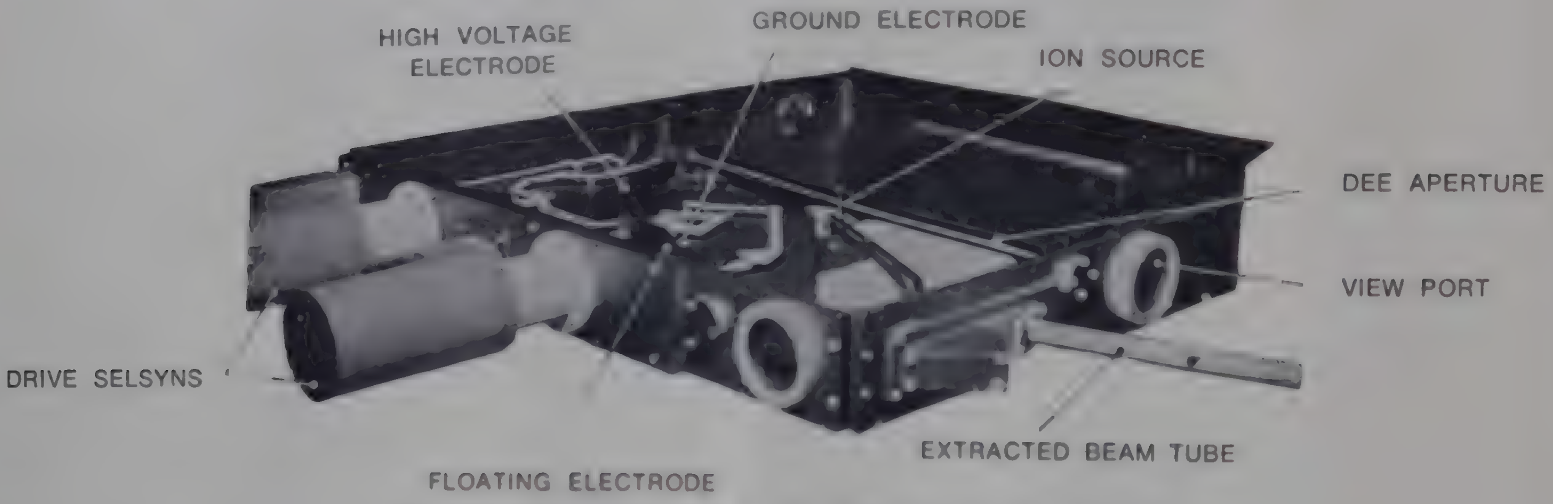

Fig. 4b. 1:5 scale model of the deflector and the dee-tank.

building being built on a 6.07 hectare plot, about 5 km from the Dum Dum airport, in the Salt Lake Development Corporation area. On the adjoining plot of 2.83 hectares will be located the new building of the Saha Institute of Nuclear Physics.

The cyclotron building is having many built-in special features. The vault and adjoining experimental areas would be covered with 102.5 cm thick concrete roof of removable slabs. An overhead 30-tonne travelling crane would handle these slabs as well as all the heavy equipment and parts of the machine during its installation. A special foundation would bear the 262 tonne concentrated load of the magnet, independent of the surrounding floor. Cables of power, control and data signals as well as pipes carrying water, air and other services would be carried through special radiation-proof penetrations laid in the thick concrete walls and floors. The foundation girders for levelling the magnet, the vacuum pumps and the main magnet power supply units would be located in a basement below the vault.

VEC Project

The proposal made to the Department of Atomic Energy, for supporting a project for fabrication of a variable medium-energy cyclotron, was based on an expert team's recommendation that considerable saving in design costs and speedy fabrication would be achieved by following an already proven design. Accordingly fabrication drawings of the TAMVEC (Texas A & M Variable Energy Cyclotron), which in turn follow the design of the 88-inch cyclotron at the Lawrence Radiation Laboratory of the University of California at Berkeley, U.S.A. are used for the various systems of the Calcutta machine. Some modifications have been made to suit the available Indian resources and fabrication facilities as well as a result of the experience gained by BARC personnel while participating in the TAMVEC installation.

The responsibility for fabrication and installation of the variable energy cyclotron at Calcutta has been entrusted by the DAE to the Bhabha Atomic Research Centre, Trombay. The Saha Institute of Nuclear Physics, Calcutta and the Tata Institute of Fundamental Research, Bombay are assisting in that task. Scientists and engineers from various diciplines, like nuclear physics, technical physics, vacuum physics, instrumentation, electronic engineering, mechanical and electrical engineering, health physics, architecture and civil engineering are working for the VEC project. It is also bringing about a much desired interaction between research institutions and industrial concerns, both in the private and public sectors, for establishing sophisticated facilities. The Calcutta cyclotron would be a national research facility which will be used

(Continued on page 9)

WINDOWS OF THE SOUL

SCIENTISTS researching into human behaviour and performance have, for some time, been looking for an efficient method of telling how their experimental subjects really feel about the task they are performing. Speech is too slow and people do not or cannot always tell the exact truth. Bodily functions controlled by the so-called autonomic nervous system can, however, provide a valuable guide to the emotional and, to some extent, mental states. And as these are not normally consciously controlled, the scientists cannot be misled.

Such things as rate of heart beat, electrical resistance of the skin and the size of the pupil of the eye are good examples of the function controlled by the autonomic system. The last is, perhaps, the most sensitive and rapid indicator of the emotional state. It is now some years since psychologists began seriously to investigate the relationship between the size of the pupil and the emotional state. But in a non-scientific way, pupil size has been used as an index of emotion throughout history. Men have always tended to find girls with enlarged pupils sexually interesting — hence the phrase the "wide-eyed look". Enlargement of the pupils indicates pleasurable interest in whatever is being looked at, so the reason for finding a wide-eyed girl attractive is that, with a bit of luck, she is unconsciously signalling that she likes you. And conjurors performing card tricks often identify the card someone is thinking of by the way in which his pupils widen when that card is turned up.

Advertising men are supporting research into this field with a view to using pupil size as an index to people's true preferences as an aid to market research. Clinical psychologists are beginning to use it as an index of their patients' progress. The applications are numerous. But the problem is how to observe and record changes in pupil size. These changes often last for only fractions of a second.

Two scientists at the Institute of Sound and Vibration Science at the University of Southampton, have now devised a successful system which uses a television camera to watch and record changes in pupil size. The first application of the device is in investigating how various kinds of noise and vibration interfere with concentration. The applications in industry and for military purposes are obvious. They have already found, for example, that while someone is learning something complex, the pupils dilate. They tend to remain dilated as long as this information has to be held in the head and to contract when it is given out and made use of. So as to measure these effects and the effect of noise on them, the Southampton scientists sit their subjects in a booth in near darkness with the head held in an ophthalmic head rest. A small mirror reflects an image of the subjects eye into a TV camera. The changes in pupil size can be seen on screen. The camera scans the eye 25 times a second which means that it can take in even the quickest widenings or narrowings of the pupil. Changes in the pupil size are also recorded by a pen recorder and stored on magnetic tape for future computer analysis. The success already achieved with this device shows that it has clear advantages over film cameras used, for the same purpose, up to now. ●

(from SPECTRUM No. 74/1970)

Calcutta Cyclotron

by workers from many research institutions, colleges and universities.

The combined cost of materials, components, fabrication and installation of the Calcutta cyclotron, including provision of necessary service facilities such as power sub-station, workshop, air conditioning equipment and salaries is estimated to be about Rs. 4.18 crores. The estimated cost of the building is Rs. 90 lakhs. According to present time schedule, major systems of the Cyclotron will be ready in 1973. ●

BARC Reporting

Biochemistry and Food Technology Division

The feasibility of using radiation for inhibition of mould growth in coconut meat (received from Industrial Testing and Research Laboratory, Trivandrum) is being evaluated. In a preliminary experiment, samples were packed in polyethylene pouches and irradiated at doses from 25 to 200 krads. From organoleptic trials the optimum dose was found to be 35 krads. Studies on the synergistic action of heat and radiation on storage properties, microbial counts and sensory attributes are in progress.

* * *

Large scale studies on disinfestation of wheat by gamma radiation have been completed. A detailed report on the storage studies including physical analysis, insect counting and sensory evaluation is being prepared.

Isotope Division

A radioisotope smoke detector using Thallium-204 source has been developed and tested. This detector is expected to have wide application in fire alarm systems.

* * *

With a view to studying dredging operations on a long range basis outside the Kakinada Harbour, a radiotracer investigation has been undertaken. Early this month 40 curies of Scandium-46 glass tracer were injected at about 6 meters depth in the open sea. Tracking of the silt movement is in progress.

In an earlier experiment to study the silt movement right outside the present Kakinada Harbour, Scandium-46 radiotracer was released during March 1970. The final phase of the tracking of this tracer has just been completed.

World Nuclear and Space

Research and Power Reactors Operating in the World

SOME 712 reactors are listed in the third comprehensive list of land-based nuclear power and research reactors in its Member States, issued by the International Atomic Energy Agency (IAEA). Of these 367 are research reactors now operating in 47 countries. The remaining 345 are power reactors in operation, under construction or planned.

The total number of power reactors operating at the end of 1969 was 91 in 14 countries, with a generating capacity of nearly 15,500 electrical megawatts. By the end of this year the total should be 109 in 15 countries, with a capacity of 24,250 megawatts. By 1976 the number of countries is expected to rise to 28 and the capacity (with 298 reactors) to 147,000 megawatts. Plans put forward indicate that by 1980 installed nuclear capacity will considerably exceed 300,000 megawatts.

The projections of major nuclear power programmes to 1976 are as follows:

Country	*reactors*	*MWe*
USA	107	76 500
UK	42	13 000
USSR	29	8 800
Federal Republic of Germany	25	10 000
Japan	19	9 500
France	11	3 000
Sweden	10	5 400
Canada	9	4 000

The number of power reactors and their output in other countries is currently expected to be: Argentina (2) 600 megawatts, Australia (1) 500, Austria (1) 400, Belgium (4) 1500, Brazil (1) 500, Bulgaria (2) 800, China (1) 500, Czechoslovakia (1) 100, Finland (1) 440, Greece (1) 450, India (6) 1200, Italy (5) 1400, Korea (1) 550, Mexico (1) 600, Netherlands (3) 1000, Norway (1) 500, Pakistan (2) 325, Spain (6) 2600, Switzerland (5) 2250, and Thailand (1) 300. This would give developing countries a proportion of just under three per cent.

Atom Powered Pacemaker Keeps Heart Beating

SINCE April this year, the heart of a 58-year old Frenchwoman has been beating regularly with the help of impulses from an atomic-powered "pacemaker." This is the first time that such a device has been used in a human being, though successful tests have been made with animals in UK and USA.

The device, described as being of about the length of a finger-nail and the thickness of a cigarette, contains 150 milligrams of plutonium-238. The heat of fission is converted directly to electricity, providing power for associated circuitry which stimulates the heart muscle at regular intervals so that normal blood circulation may be maintained, thus correcting a condition due to a particular malfunctioning of nerves.

Electronic pacemakers have been used by surgeons for years; thousands of people are now alive who would be dead but for their support. But these devices have suffered from the drawback that their batteries have a life of no more than perhaps 30 months, after which the battery must be replaced. The atomic-powered pacemaker has been designed to last ten years.

Similar devices have been developed in several countries, and a number have been used in experiments with animals. The one used in this operation was developed by Dr. Paul Laurens, of Broussais Hospital in Paris, who with Dr. Armand H. Pivnica attached the pacemaker to the inside of the woman's chest cavity just above the diaphragm. Wires leading from it were embedded in the woman's heart muscle. An important feature is that the device lies quiescent for as long as the natural heartbeat is adequate to keep up normal blood flow. When the heart-rate falters the pacemaker takes over automatically.

The two doctors appear to have overcome a major safety problem, in that more than ninety per cent of the radiation from the plutonium source is said to be absorbed within the protective sheath of the capsule, made of tantalum and platinum. The capsule has been designed to withstand temperatures of up to 3000°C, shattering and corrosion. The amount of radiation actually released in a year is said to be equivalent to no more than the woman would receive from a single chest X-ray.

Science writers in newspapers and magazines have speculated that this operation—which appears to have been successful—may foreshadow the day when nuclear energy will be used for competely artificial hearts, on which design studies are already well advanced, or other devices to assist bodily functions. *(IAEA Bulletin,Vol, 12, No. 3, 1970)*

Japan's Space Efforts

WITH the successful launching (on February 11) into earth's orbit of its first artificial satellite, Japan became the world's fourth nation to do so after the Soviet Union, the US and France. The 23-kg. satellite, containing signaling equipment, was launched aloft by the four-stage Lambda 4S5 rocket.

Space activities can be classified into two categories: the scientific exploration of outerspace and the practical application of artificial satellites to such fields as communications, meteorological measurements, navigation, and geodetic surveys. In Japan these two types of space activities have been carried on both by Government agencies and by universities

esearch Round-up

along the lines set forth by the National Space Activities Council and the Space Activities Commission. The Council was established in 1960 as an advisory organ to the Prime Minister to conduct investigations and deliberations on important matters related to space development. The Space Activities Commission and the National Space Development Agency of Japan (NASDA) were established at the request of the council.

The Space Activities Commission was established in place of the National Space Activities Council in 1968 to deliberate and decide on important space programmes, compiling estimates of expenditures, and overall co-ordination of the activities among related administrative organizations. It adopted on October 1, 1969, the Space Development Programme upto fiscal year 1974. The commission urges in the programme that scientific satellites, experimental application satellites, including a stationary satellite; and rockets for launching them should be developed, and scientific research of space and experiments for its utilization using these satellites should be conducted.

Leading Roles

NASDA, established in October 1969 taking the place of the former National Space Development Centre, is the central organ for the development of launching vehicles and applications satellites.

The University of Tokyo through its Institute of Space and Aeronautical Sciences and under the direction of the Ministry of Education plays the leading role in the scientific exploration of outer space. Exploration has been carried out by means of sounding rockets, balloons and ground observation. Gradually, however, progress in rocket techniques has made it possible to manufacture launching vehicles capable of lifting artificial satellites into orbit.

The Institute of Space and Aeronautical Science, the National Aerospace Laboratory and NASDA conduct research and development of launching vehicles and sounding rockets in Japan. Each organization has already developed various types of rockets.. Matters connected with the establishment and operation of the actual satellite application systems are managed by the authorities best prepared to handle them. The Ministry of Posts and Telecommunications, the Nippon Telegraph and Telephone Public Corporation and the Japan Broadcasting Corporation have each decided to undertake research and development of satellite communications systems in anticipation of the launching of experimental application satellites.

The Research Co-ordination Bureau of the Science and Technology Agency is the comprehensive Governmental control organ connected with the nation's space development.

NASA Plans Grand Tour of Deep Space Planets

THE National Aeronautics and Space Administration of the USA has announced plans for two reconnaissance flights in 1972 and 1973 — "man's first venture beyond the orbit of Mars into the outer solar system."

These two spacecraft — both unmanned — will penetrate the belt of 50,000 asteroids and speed on to Jupiter, making photographs and scientific observations within 100,000 miles (160,000 kilometres) of the giant planet, before passing on into deep space.

Each of the two Pioneer spacecraft will take about two years to travel the 500 million miles (800 million kilometres) to Jupiter. They will spend about a week swinging around the planet.

"One goal of the mission," says NASA, "is to assess hazards in deep space and to develop technology and operations experience for grand tour missions to the outer planets — Jupiter, Saturn, Uranus, Neptune, and Pluto — planned for the late 1970's."

Pioneers F and G will each weigh about 550 pounds (247 kg.) and will carry 60 pounds (27 kg.) of scientific equipment. They will be launched from Cape Kennedy.

The spacecraft will spend more than six months passing through the asteroid belt which circles the sun from 180 million to 330 million miles (288 million to 428 million kilometres) from earth. The asteroids range in size from the 480-mile (768-kilometre) diameter Ceres to bodies only a mile in diameter. Their combined mass is believed to consist of enough material to form a small planet.

In the asteroid belt, spacecraft instruments will measure and report to earth via telemetry such things as the intensity of sunlight reflected from the asteroids and the overall quantities of cosmic dust. Near Jupiter, the Pioneers will gather information on a number of mysteries surrounding the planet.

"Red Spot"

Much about Jupiter is still unknown. Scientists do not know whether its surface is solid, liquid or gas. Nor do they understand why a planet with a diameter eleven times that of earth rotates more than twice as fast as earth. Also unknown is the nature of Jupiter's "red spot", a feature which drifts very slowly about the planet, completing an orbit three times during the past 200 years. The pioneer instruments may provide clues to the cause and nature of the "red spot."

Also of major scientific interest are Jupiter's periodic huge surges or radio noise. It is believed to be the only planet in our solar system that radiates more energy than it absorbs from the sun. This may mean that on Jupiter dynamic processes very much like those of the sun are at work. Spacecraft measurements of Jupiters's magnetic field may help answer such questions. ●

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